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AGRICULTURAL OFFICERS.

The Training of Agricultural Officers.

A short time ago a brief reference was made in these pages to the Conference of Directors of Agriculture which was held this summer in London under the Chairmanship of the Agricultural Adviser to the Secretary of State. Of several subjects discussed at the Conference, one of special importance to the Imperial College of Tropical Agriculture was that of the training of Agricultural Officers. In this connection the delegates from Oxford and Cambridge Universities and from this Institution were fortunate in having placed before them the views of senior Agricultural Officers representing all parts of the British Tropics.

At the time of the Conference it was feared that the world economic crisis might lead to a curtailment of the vacancies available for scholars in the Colonial Agricultural Service and that in consequence, the continuity of the existing scholarship scheme might be jeopardized. Both these possibilities had to be envisaged in the light of their effect on Schools, Agricultural Colleges and Universities now providing facilities for the preliminary training of prospective scholars, and on the future efficiency of the Colonial Agricultural Service. It is generally recognised that the work of the Departments of Agriculture is necessary to safeguard the general agricultural prosperity of the tropical Colonies and that to achieve this end the *personnel* of these official bodies must be kept at full strength and be recruited from the best available sources. The Conference, therefore, not only recorded its appreciation of the high standard that has now been attained in the training of Agricultural Officers, but also emphasized the necessity for the continuance of the scholarship scheme.

The senior staff of a Department of Agriculture may, broadly speaking, be stated to consist of two categories of officers, of which one is mainly connected with administrative and the other with research work. The former, known as a general agricultural officer, must be able to handle practical problems in the field. The latter, on the other hand, is expected to give expert advice and is responsible in his capacity as "specialist officer" for conducting research on such problems as may arise from field investigations. While the functions of these officers are in a sense quite distinct they must, while carrying out their respective duties, and to ensure the efficiency of a Department, keep in touch with each other.

While it would appear that the types of men required to fill posts in the Agricultural Service are more or less clearly defined, the material which presents itself for training is far from homogeneous. There are, for instance, some post-graduate students who have a sound grounding in pure science but little knowledge of practical agriculture. There are others, on the other hand, who are well versed in general agricultural subjects but weak in science. The difficulties of training become apparent when it is realised that each type of student must be taught with the object of fitting him for efficient administrative service. Students who have specialised in a subject, such as entomology or botany present a simpler training problem, but it will generally be found that they will require additional knowledge for the proper handling of practical problems. In view of these anomalies, the training afforded at the College has had to be varied to meet individual requirements. All post-graduate students attend a standard course of lectures, their other work and particularly their field problems being closely supervised by their Professors. By the selection of suitable individual problems this system has now been organised as part of the general College research programme.

The Conference agreed generally with the system of training followed, and, but for a few minor modifications which are now under consideration, was of the opinion that it should be continued on its present lines. There was a considerable divergence of views with regard to the provision of "specialised training" in administrative work. Training of this kind, however, cannot be satisfactorily dealt with in Trinidad unless the requirements of the Departments of Agriculture are known in advance. So far, it has been found impossible to inform the College of such requirements with the result that it has not been possible to meet particular demands. In any case, the post-graduate course in Trinidad is not intended to provide instruction for specialised administrative work. On the contrary the principle of giving as broad an outlook as possible on tropical agriculture has been followed with a view to forming a sound foundation for future administrative experience. At present, the opinions held in regard to the actual functions of Departments of Agriculture still appear to be of a contradictory nature and in this respect this Institution would welcome further enlightenment. Definite statements of policy would go a long way towards effecting suitable changes in the present system of training, as would information regarding the probable destination of students.

The Colonial Agricultural scholarship scheme may be said to be still in the experimental stage and is undoubtedly capable of improvement. But such improvement cannot be achieved without the full co-operation of the Departments of Agriculture. The views expressed at the Conference are therefore not only welcome, but will receive the serious attention of the Academic Staff of the Imperial College. The suggestion of strengthening the economic side of the training and of impressing students that agriculture is an industry which must essentially be run on profit-making lines, will be kept in mind. A criticism fairly generally expressed by the delegates was that the experimental outlook had been over-stressed, while practical aspects of agriculture had received inadequate attention. The greatest need, at present, appears to lie in affording more facilities, especially land, for improving this side of the training. Much has already been done by altering the courses of lectures, by organising field excursions and above all by setting field problems which have brought the student into close contact with the practical difficulties of local planters.

It is generally admitted that the scholarship scheme has resulted in the recruitment of good types who have satisfactorily met the needs of the various Departments to which they have been appointed. The Colonial Agricultural Service thus emerges as a possible career for young men of sound education and a bent for agriculture. By suitable selection from such material a high standard of candidates for the service will be maintained. Point will be given to subsequent training if particular requirements are specified. The Imperial College of Tropical Agriculture, as the penultimate link in the training scheme hopes, therefore, that this Conference may form the first step towards the establishment of more intimate relations between itself and the several Colonial Departments of Agriculture.

Dr. MYERS' VISIT TO HAYTI.

Dr. J. G. Myers left Trinidad at the beginning of June for Haiti, where he was engaged in collecting egg-parasites of the sugar-cane root-borer for shipment to Barbados. He took the opportunity to carry on further explorations for parasites of cane moth-borers and froghoppers. All the work was, however, very greatly delayed by the literally terrible condition of the roads, which together with the bridges had been nearly washed away by phenomenal heavy rains. For some time this rendered long distance travel almost impossible by car. However, through the good offices of Mr. J. H. Magowan, O.B.E., British Chargé d'Affaires, and of the Service Technique de l'Agriculture, the officers of the U.S. Marine Corps and of the Garde d'Haiti gave most generous help in transportation by scouting-planes and motor-boats. En route to Haiti and also on returning, some days were spent in Porto Rico investigating there other egg-parasites of the cane root-borer, and a shipment of these were sent to Barbados. Through the great courtesy of the Commissioner of Agriculture, he was enabled to see a very great deal of the Agriculture of the Island under the official guidance of Dr. M. D. Leonard, Entomologist to the Insular Department of Agriculture. Before returning to Trinidad on the 1st September, Dr. Myers spent a week in Antigua to see the progress of Mr. Box's research work on the moth-borers of cane there.

SUGAR-CANE BORERS.

The Mass Breeding of Trichogramma minutum to Control *Diatraea saccharalis* in Barbados during 1930.

By R. W. E. Tucker, M.A., B.Ed.

Preliminary accounts on this work have been published in *Tropical Agriculture* Vol. VI, No. 8, and Vol. VII, No. 11 (8) and (9). The following account gives details, including costs, of the technique which has been found suitable to West Indian conditions, and outlines the results obtained from two years' field liberations in Barbados. The severe drought which prevailed throughout the last season's operations was detrimental to the work of the parasites during that period and also resulted in a short and abnormal cane crop. In addition, it was necessary to alter the method of sampling the crop, and to increase the number and range of samples taken, in order to evaluate the damage done by *Diatraea* and to estimate the presence and effect of *Trichogramma* in all areas of the Island. The figures obtained therefore will be directly comparable with future results, but are not directly comparable with those previously given. Nevertheless, field results show a steady lowering of the population level of *Diatraea*, an increase in total parasitism of *Diatraea* eggs, and a continued diminution in the total loss inflicted in field and factory by this pest. These results are, moreover, almost universally endorsed by the observations and opinions of planters and factory managers throughout the Island.

Although the technique described is considered suitable for West Indian conditions and labour, adaptable to smaller, or much larger scale operations, and economic in practice, it is realised that the output of parasites described is not yet adequate for complete control and crop protection in Barbados. Experience has shown that the more frequent and widely spread the liberations are, the more effective is the control over the area treated, and every effort has been, and will be made to increase the output of parasites by additional moth breeding units, increased corn supplies, and larger and more rapidly available outputs of the host moths, *Sitotroga*. It has been impossible to limit and concentrate the available parasites in one section of the Island only, and to refuse distributions to any particular area; it was equally impossible to start off with the numerical production of parasites which it is hoped gradually to attain. Nevertheless it is considered that the present procedure has achieved satisfactory results and will meet with increasing success.

Briefly put, the procedure is to establish the parasite as early as possible throughout the young growing crop and to maintain a parasitism above normal over a period of several months. At least 2,100 parasites are evenly distributed per acre at each liberation and as this means that one cardboard slip containing about 170 parasitised eggs is placed in every 10th cane stool, chessboard fashion, the spheres of action of these colonies should approximately touch and should certainly overlap in the first field generation. It is realised that the present output necessitates a small percentage of estates, and a certain number of fields on each estate, having to rely on wind drift for an increase in normal parasite population which is a great drawback, as is also the fact that distributions to every area of the Island are made only once every three, or occasionally two weeks, instead of at least once every week.

The writer hopes to attain a uniform and continuous distribution of parasites and to make adequate annual determinations of host population level and of total crop damage, in order to evaluate the work of *Trichogramma*; but perfection in production and distribution of parasites, and in determination of results obtained over the whole crop, are hardly likely to be obtained. Anything approaching perfection in the economic control of insects whatever the method adopted, or in the assessment of control obtained is, it must be admitted, rather the exception than the rule.

Production of Parasites in 1930.

In 1929 a total of 22,816,700 parasites was liberated (numbers liberated represent seven-eighths of the total numbers bred; the remaining one-eighth being absorbed as breeding stock). In 1930, liberations amounted to 35,930,000. In addition 2,160,000 parasites were liberated in January and February, 1931, making a total of 38,090,000 liberated, or a total of over 43,500,000 bred from the operation of four *Sitotroga* units containing a total of 12,000 lb. of corn. This compares favourably with Flanders' (2) record of 30,000,000 parasites available for liberation for breeding in which 25,500 lb. of corn were used, and Hinds and Spencer's (4) record of 10,000,000 parasites from the use of 100 bushels or about 7,000 lb. of corn. During the present season of 1931, 14,000 lb. of corn are being used in the *Sitotroga* units, but it is realised that even so, the production of parasites will not be entirely adequate for proper treatment of the whole Island. A definite reduction in the pest and its damage has been obtained, but further experience is still necessary to ascertain the requisite minimum number of parasites which must be liberated in a given area in any one season to obtain complete control, though the writer does not think that so far as sugar-cane and *D. saccharalis* are concerned it will be necessary to liberate the million parasites per day per small area which has been stated by one critic to be essential for the achievement of definite results in this work.

Hindrances to Production.

Various hindrances to the mass breeding of *Trichogramma* have been described by the writer in (9) and (10). Those encountered in the past have been successfully overcome, but other drawbacks have developed. Thus the corn used in 1930 was sterilised by passing it through a Simon's Heater; but this reduced the moisture

content of the corn below the optimum for *Sitotroga* breeding. The result was that fewer and smaller moths bred out, and the yield of eggs was diminished: the situation was further aggravated by the heat and drought which prevailed throughout the season. This year the corn was fumigated in the breeding units, for two or three days, using an overdose of hydrocyanic acid. This has not interfered with the subsequent breeding of *Sitotroga*, and together with sulphur at the rate of 5 lb. to 3,500 lb. of corn has so far resulted in the moth units being free from pests other than the rust red flour beetle *Triboleum ferrugineum*. This pest has been shown by Alden and Farlinger (1) to feed on *Sitotroga* eggs and dead moths, and as it is difficult to exclude, and is a rapid breeder, it is capable of inflicting considerable damage. One moth breeding unit was unfortunately badly infested by this beetle early this season, and has given very poor results compared with others which developed a later, and much less severe infestation. A certain measure of control is obtained by taking advantage of the habit of this beetle of clustering in masses in confined, dark places. Boards are laid on the floor as traps and from these and all hiding places such as between trays and racks, and under trays, &c., many thousands of beetles are swept daily into receptacles containing oil emulsion, or crushed; the floor is also washed from time to time with hot five per cent. carbolic solution.

Results obtained from Parasite Liberations.

To evaluate the results obtained by the liberations previously described it is necessary to estimate the host population level week by week over a period of several months, and simultaneously to ascertain the extent of parasitism by *Trichogramma*; in addition the total damage inflicted by the pest on the crop at the period of reaping must be assessed annually.

The estimation of the host population level is made by weekly or fortnightly collections and counts of eggs deposited by the moth at as many points as can be regularly visited over the whole Island. The writer and a field officer together make about 80 collections each month in an average of 40 fields, the same area of each field being examined, and the eggs removed, at least twice a month. This gives a fair indication of the number of moths available for laying eggs. The extent of parasitism is naturally easily ascertained. While the cane is still young, counts of dead hearts per 100 stools are made in random selected fields; the figures thus obtained are an index of moth prevalence. Finally, the extent of moth borer presence in the canes at the period of reaping is ascertained by careful counts of damaged and undamaged joints in numerous samples representative of the crop as a whole, selected from about 60 estates scattered over the Island. From the percentage of joints bored, the factory loss is obtained; which, when added to the field loss as ascertained by examination of 100 stripped stools in each of 136 random selected fields, gives the total loss to a fairly accurate degree for the area treated. It is hardly possible however for any system, except an examination of a considerable sample of cane from *every field* in the whole Island, to give an accurate estimate of moth borer prevalence and damage, for the following reasons. The degree of infestation of the cane varies according to the following factors: (*a*) variety of cane (*b*) whether plant or ratoon crop (*c*) situation of field whether sheltered or wind swept (*Diatraea* larvae are wind borne), damp or well drained, flat or on side of hill (*d*) rainfall and temperature during growth of crop (*e*) vigour of growth and size of canes (*f*) stage of growth at which estimate of infestation is made (*g*) initial infestation of field, whether from infested seed or from adjoining reapable cane (*h*) number of liberations of *Trichogramma* made in or near to fields from which samples for estimates are taken.

The latter factor may apply only to Barbados, but the other factors are fairly universal and will assist in making clear the natural difficulties, apart from technical or staff difficulties, in obtaining accurate and comparable annual estimates of the degree of *Diatraea* infestation over a large area.

Nevertheless, the estimate of total loss of crop reaped in 1929, was 31 per cent. (parasites liberated would not have affected this crop) the total loss in 1930 was 20.85 per cent. and as recently estimated for the crop reaped in 1931, 16.6 per cent. The percentage infestation of cane joints in 1930 (first of these estimates made) was 38.5 per cent. In 1931 the corresponding figure was 30.0 per cent.; both these figures are for bored canes only, and do not include the unbored joints in the proportion of totally unbored canes present in the crop. If the correct proportion of unbored canes are included in the crop samples taken in 1931, then the percentage of bored joints is 27.3.

In addition, the results of the regular field counts of eggs made as described above show a steady decrease in the number of moths and a satisfactorily high, and slightly increasing, parasitism of eggs in spite of the smaller number of eggs present.

There is therefore definite evidence of a lowering in the host population level, and of diminution in damage inflicted. This is borne out by the almost universal opinion of planters and factory managers accustomed for generations to the growing and milling of cane; their observations, voluntarily given, are that there has been (*a*) fewer dead hearts (save for an occasional bad field here and there) (*b*) fewer tillers killed by borer during the growing season (*c*) fewer badly damaged or rotten canes left in the field (*d*) less discoloration of megass at the mills due to borer injury (*e*) an increased purity of juice.

It must be mentioned that the method of sampling the crop in 1929 and 1930 in order to ascertain the total loss in the field, entailed too

SUGAR-CANE BORERS

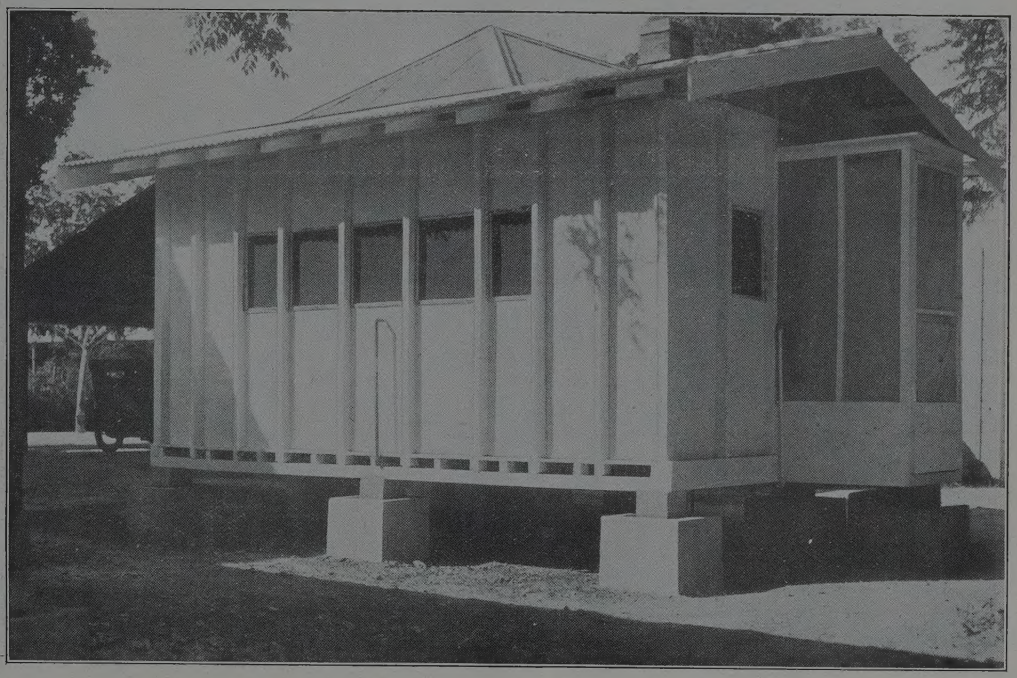

PLATE 1. *Moth Breeding Unit.*

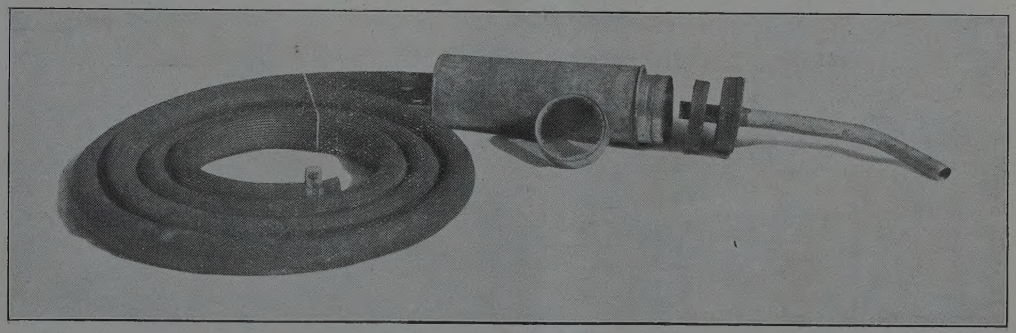

PLATE 2. *Apparatus for collecting moths.*

SUGAR-CANE BORERS.

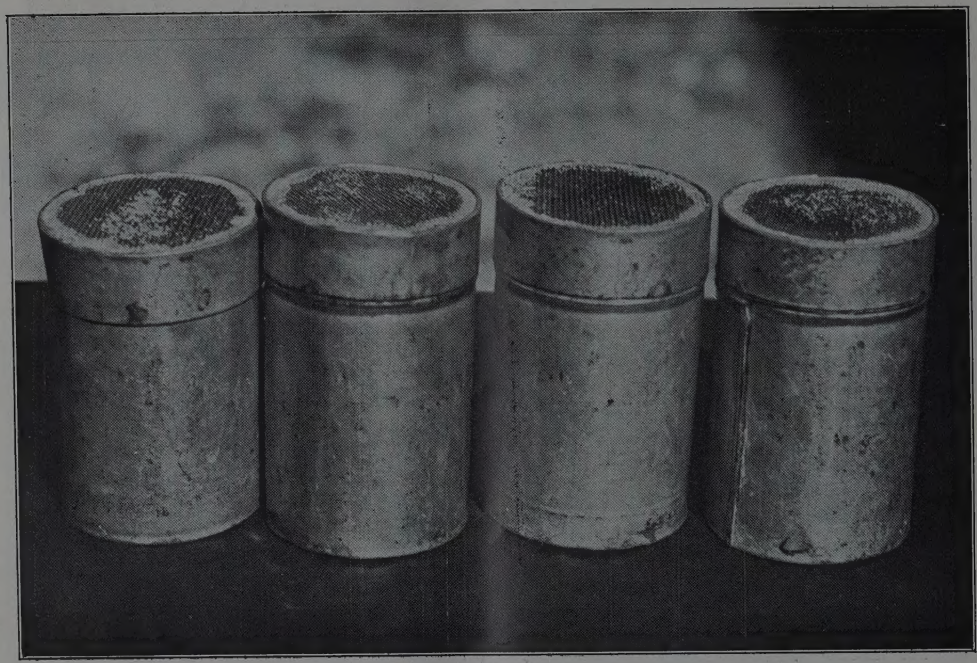

PLATE 3. *Tin cylinders with eggs adhering to gauze caps.*

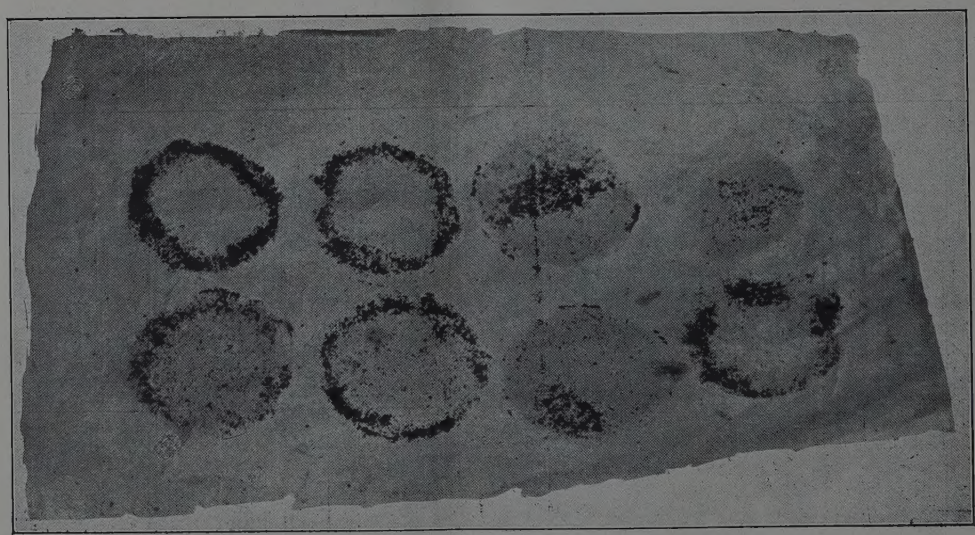

PLATE 4 *Showing method by which egg masses are deposited between gauze and paper.*

SUGAR-CANE BORERS.

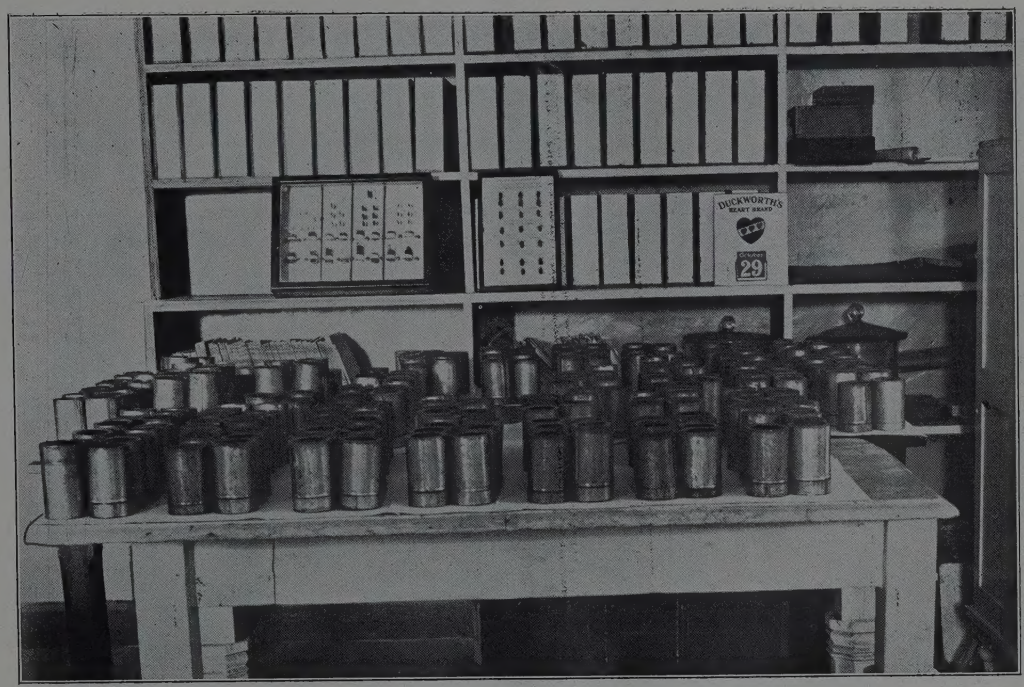

PLATE 5. *Tins arranged for egg deposition.*

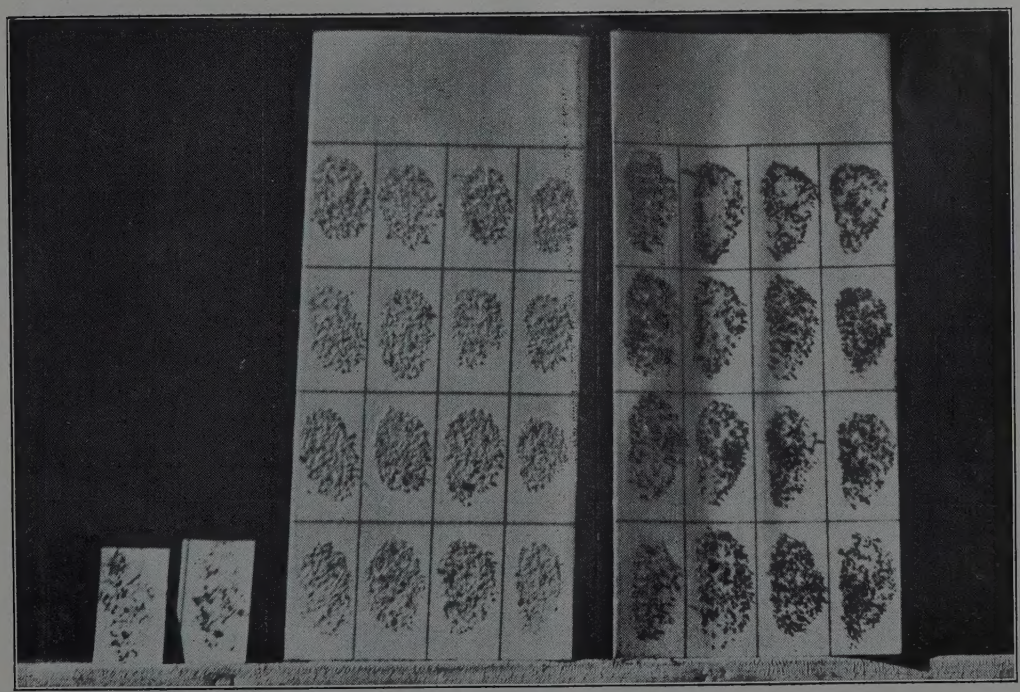

PLATE 6. *Sheets of egg sections: on left, unparasitised; on right, parasitised.*

SUGAR-CANE BORERS.

PLATE 7. *Gauze capped tubes each with four sections of parasitised eggs.*

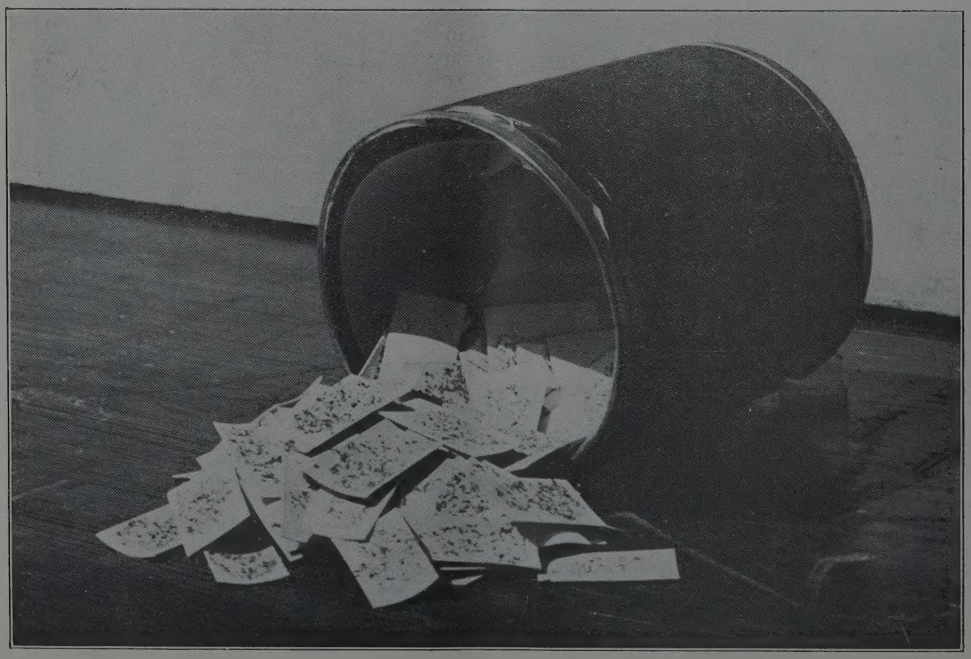

PLATE 8. *Tin containing 192 sections ready for distribution.*

much detailed work and expert supervision to be applied on a sufficiently large scale to sample the crop of the Island as a whole. In 1931, in order to obtain more adequate factory and field samples, different workers and slightly different methods were employed; and as far as possible, the personal factor was eliminated so that future changes in the workers taking samples would not greatly matter. Altogether, about 12,000 canes were examined at twelve factories drawing crops from all areas of the Island. From these, 2,250 canes were taken at random, but containing the proportion of badly bored, slightly bored and unbored cane which each factory analysis revealed; these canes were dissected joint by joint to obtain the proportion of bored joints given above. The estimate of loss due to cane rendered unreapable in the field was made as follows. One hundred and thirty-six fields, representative of all areas of the Island were selected at random and 100 stools in each field stripped of all trash; workers then recorded the number of canes reapable and unreapable. No attempt was made to ascertain the amount of cane rendered unreapable from causes other than borer; it is all classed as killed by borer, or from the results of borer lesions, though possibly up to ten per cent. may be killed by other causes. The results obtained from this field examination of 13,600 stools comprising 151,289 canes was 11.1 per cent. unreapable and 88.9 per cent. reapable. The figures ranged from 4.3 per cent. to 21.2 per cent. unreapable; the areas with the lowest amounts of unreapable cane and the highest figures for unbored cane were invariably those of greatest parasite liberation. The factory loss amounted to 5.5 per cent. of the crop (average reduction in sucrose in joints due to borer is 20.2 per cent.; with an average joint infestation of 27.3 per cent., the loss in harvestable cane is 27.3×.202 or 5.5 per cent.); this added to the field loss just given makes the total loss for 1931 as 16.6 per cent. of the crop. Future estimates will be made on this plan and will be comparable with the figures for 1931. Though it is considered that no estimates of loss or of host prevalence over the whole area treated can be made really accurate, a sufficiently definite diminution in borer damage is revealed to show that a noticeable control is being obtained; and, as stated, this is borne out by the opinion of the people growing and handling the crop.

Breeding Technique.

The details of mass breeding *Trichogramma minutum* are best illustrated by Plates I to IX.

Plate I shows one of the four moth breeding units. Each one now holds 3,600 lb. of corn, in 90 horizontal trays in a large central rack (during the first two mass breeding seasons, only 3,000 lb. of corn were placed in each unit). There is ample room inside for moving around, collecting moths by vacuum, and supervising trays for pest control. The units are ant-proof, capable of being sealed for fumigation and reasonably pest-proof, save by the entrance door, which is safeguarded as far as possible by the ante chamber shown. The latest mechanical devices mentioned by Flanders (3) for collecting moths are not employed as the economic necessity for them is not apparent in Barbados, and the yields of moths and parasites obtained by existing methods compare very favourably with those given in any other published accounts.

The pipes carrying vacuum from a central engine are seen entering the side of the unit and ante chamber.

All units built in the future will be provided with ventilating cowls in the roof. At present all units are equipped with electric fans inside, but this year it has been necessary to spray the roofs and walls several times daily with water in order to keep the temperature below 90° F.

Plate II shows the apparatus for collecting moths. The stout hose is fixed into a nozzle of the vacuum piping inside. A collecting cylinder is shown partially slid into the metal container, in which it rests on a cotton wool pad. A lid, through which passes the end of the tube, which, with its cork fits into the mouth of the container, is shown detached. The normal gauze lid of the collecting cylinder is shown at the side. Moths are sucked by regulated vacuum through the metal tube into the collecting cylinder, and when 200-250 moths are in the cylinder, the collecting tube and cap are removed, and the gauze lid fitted on whilst the vacuum holds the moths in the cylinder. A fresh cylinder is then inserted and by this means the moths are rapidly collected in an undamaged condition into the receptacles in which they lay their eggs. The cylinders of moths are then placed in a separate room on sheets of paper on ant-proof tables (Plate V) and the moths deposit their eggs overnight between the gauze caps and the paper sheets. Various innovations employed by other writers for increasing egg production have been tried, but results so far have not justified a change from the method described.

Plate III shows four cylinders with eggs adhering to centre and sides of the gauze lids.

Plate IV shows a sheet of paper on which eight tins have rested, showing the masses of eggs deposited on the paper as well as on the gauze of the lids.

These eggs are cleaned of moth scales and debris and are brushed off into clean glass containers.

Plate V shows over 120 such tins on their sheets of paper ready for egg deposition. Sometimes tins are retained for three nights and three layings obtained from the moths; usually the majority are only retained two days, and when discarded, all moths living and dead, are placed in a specially built receptacle of corn, so that any larvae which hatch from eggs so obtained will not be lost, but are eventually received, much multiplied, *via* the moth units.

Plate VI. These sheets were devised by the writer as being the most convenient for breeding work and distribution. Two of them fit exactly into a glass tube six inches by one inch. They are cut and printed in bulk; and workers soon

become adept at applying patches of gum arabic evenly on each section, on to which the cleaned *Sitotroga* eggs are dusted, the surplus shaken off, and the sheets allowed to dry. The eggs on the sheet on the left in Plate VI are unparasitised; those on the right hand sheet are parasitised. To obtain a parasitism as depicted, two parasitised sections, as shown on the extreme left are required; this gives a *routine eight fold reproduction.* Very often, only three sections are placed in a tube with two sheets of eggs, thus giving a tenfold reproduction. At the end of the day's work, any surplus or swept up eggs, or those obtained by cleaning the inside of the tins, are returned to the moth units.

Plate VII shows an array of gauze capped tubes each containing four sections of parasitised eggs. These sections are placed in the tubes 24 hours before the sheets of eggs are inserted. The parasites thus emerge several hours before the sheets are put in, and mating of parasites before oviposition is thus assured. The sheets are easily inserted without damaging or losing any parasites by keeping the closed end of the tube towards a strong light, and tapping the tube sharply as each sheet is inserted.

On the sixth to seventh day, twenty-four hours before the parasites are due to hatch, the sheets are cut up into sections, and the sections placed in cigarette tins as shown (Plate VIII). In each tin 192 sections are placed, which will give an estimated yield of twenty-five to twenty-seven thousand parasites. These tins are then placed in cool storage at 40° to 45° F. and are distributed from thence to planters who are invited in by printed post cards to fetch and distribute the sections in their fields.

It may be mentioned that the number of parasitised eggs per section is averaged each week for a large number of sections, to ensure that the sheets are properly made up, and above all, that the number of parasitised eggs per sheet keeps constant. A number of sections are also placed in separate small tubes, and the parasites hatching out are counted, and the percentage hatch of parasites determined. In this way it is always known whether the rate of parasitism and percentage hatch of parasites is remaining normal, and from the figures obtained, weekly computations of the parasites bred and liberated are easily made, from the standardised sheets.

The average number of parasitised eggs obtained per section is 170, and the average hatch of parasites is 84 per cent. The number of eggs per section naturally varies somewhat, but the average for a large number remains fairly constant at the figure given. The percentage hatch of parasites rises as high as 90 per cent. but never falls below 80 per cent. and it speaks well for the ease in which this parasite can be mass handled that this steady output can be maintained as a routine procedure over several months. When computing the numbers of parasites reared, the percentage hatch is taken as 80, though as stated the average is higher; any figures given therefore are not overestimated.

Should any considerable variation occur in the number of parasitised eggs per section, or in the percentage hatch, the reason is at once sought out. Given steadiness in the gumming and preparation of the sheets, the only factors causing any variation in the above routine have been lack of scrupulous cleanliness in the glass breeding tubes, and excessive heat in the parasite room. The first point is a matter of organisation and supervision; the second however is more serious, and if the temperature in the parasite breeding room rises to above 90°F. there is usually a wholesale mortality of parasites and a resultant poor parasitism of eggs on the sheets. Already this season excessive heat has given trouble; and then, on adapting a cooler room to meet the need, incorrect lighting of the tubes resulted in diminished parasitism, until remedied. After that, routine production became normal once more.

Plate IX shows the method of distribution of eggs slips in the field: parasites are due to hatch within a few hours of being placed as shown and the risk from ants or other predators is not considered serious during the short period before the parasites hatch in the field.

Cost of Mass Production of Trichogramma.

As stated, a total of 43,500,000 parasites were bred, and 38,090,000 liberated during a period of 12 months and it is considered by the writer that more should have been obtained. To obtain these numbers equipment to the value of £550 was used, and £100 worth of corn was employed. The equipment will last for a long period of years but counting its life at five years only, a capital expenditure of £110 per annum can be entered. Other expenses including all salaries, overtime, painting and repairs to units, renewals of equipment, refrigeration and electricity amount to £1,120 a year. The total expenditure per annum therefore is £1,330 for which protection is given to 35,000* acres of growing cane annually. This amounts to 9.12*d.* per acre per annum or, excluding salaries, and counting capital and working costs of £380 per annum, the amount is 2.6*d.* per acre. If the latter figure were doubled it would still be an exceedingly cheap protection for a crop valued at £17 per acre even in the present severely depressed times.

Suggestions for Adequate Control of *Diatraea saccharalis* by *Trichogramma minutum.*

The results achieved at the cost, and with the equipment, outlined above are sufficiently satisfactory to warrant an increase in the output of parasites sufficient to give complete control of the pest over the whole Island. The question then arises as to what would constitute a sufficient output, would its operation (production and distribution) be a practical proposition, and would it be economic?

* Report on West Indian Sugar Commission, 1930.

If funds were available, and it were possible immediately to increase the output of parasites in Barbados, the writer would suggest the following procedure. The present moth breeding equipment would be increased from four units to a minimum of eight, or to preferably a maximum of ten units. These units would then be put into production as follows: at the beginning of February, three units; begining of March, four; April, five; May, seven; June eight or nine and at the the beginning of July the maximum number of ten units would be in full swing. Postulating then the smooth running of the units, that is the exclusion or control of pests and parasites therein, and good corn and healthy *Sitotroga* stock, there should be five to six million parasites available throughout February, eight to nine million, in March, 12 to 14 million, in April and progressing upwards to well over 20 million in July which would be maintained around 20 million throughout August and September and would then decrease from thence onwards to about seven million a month in December. These numbers are only approximate and could no doubt be considerably exceeded if all went well, though it is difficult to say how soon the first two or three units would cease to produce worth while numbers of moths; units have been kept in production here for eight months, but it would be better not to count on longer than six months productivity.

During February and March, liberations would be more diffuse than at present: that is instead of 2,100 parasites (15 slips of parasitised eggs) per acre, the number of parasites per slip would be reduced, to give around 1,000 per acre. By this means, the output of parasites would be sufficient to give every estate in the whole Island parasites every other week. This amount would not be sufficient to treat every field in each estate, but it is the writer's opinion that the sphere of action of *Trichogramma* in a field of young cane from two to three feet high greatly exceeds the 25 feet diameter mentioned by Flanders (6). In a perfect calm, these small insects most probably would have a very restricted range; also in a high wind they would undoubtedly cling to their support and move as little as possible save by walking, but in light breezes the writer is convinced that, as in the case of many small wingless insects and mites, *Trichogramma* can travel considerable distances possibly descending at will; moreover, though definite proof under normal field conditions can hardly be obtained, it is considered that there is more than mere random movement in the finding of host eggs by *Trichogramma*.

Hence, a diffuse liberation as mentioned over the whole area of young cane during alternate weeks of February (*i.e.*, half the Island covered one week, half the next) followed in March by a similar diffuse liberation over the whole Island *every* week, and in an increased number of fields on each estate, should secure the destruction of a large proportion of *Diatraea* eggs before they could hatch. Subsequent to this, various factors would operate to destroy around 90 per cent. of the larvae hatching from unparasitised eggs.

There would at this period be a large amount of fully grown cane awaiting reaping or being reaped; some parasites might drift or migrate into these fields, but the latter usually contain in themselves a considerable population of *Trichogramma*, and it is certain that normally a considerable number drift or migrate out of such fields into nearby young cane; and the exchange would possibly balance.

In April, sufficient parasites would be available to treat every alternate acre or field * in the Island every week with an increased number of parasites, the actual number depending on, and being calculated from, the number of parasites being bred out.

The increased number liberated per acre would be obtained by the simple expedient of increasing the number of eggs gummed on to each of the sections as cut up for distribution, and it is considered that whilst the cane is still young, and under four feet high (up to about June) that small liberations in every alternate field or acre *regularly every week* would be more effective than larger liberations at longer intervals in a lesser number of fields.

As the canes increase in height, and the natural range, and to a less extent wind borne range of the parasites, is restricted, then the numbers liberated per acre would be increased, up to or beyond the present figure of 2,100 per acre, and each estate would receive parasites every week; but at the above figure fewer fields, or less than every alternate acre would receive parasites. By then, however (about August), they should be well established in every field, and it would be more advantageous to liberate between two and three thousand parasites per acre in a restricted number of fields each week from August onwards than to continue the more even and more diffuse liberation suitable to conditions earlier in the year in young cane.

In August at the latest, the first moth breeding units would be thrown out of production and overhauled, repainted, &c., for next year's work; and in succeeding months other units would follow and production of parasites diminish until by December only a few million parasites would be available per month for the newly springing cane.

This breeding work could be handled by the present organisation and routine in Barbados, with the addition of three or four unskilled workers. The initial outlay for new units, equipment and corn would be around £800, which is not excessive considering the value of the crop to be protected and less than the cost of many fruit estate spraying programmes. The annual running cost would amount to only a few pence per acre.

This, then, to the limitation of conditions as existing in Barbados, supplies an answer to the questions of adequate output and cost. As to

* The majority of fields in Barbados are about five acres in extent. The average for 684 fields worked out at 5.92 acres per field.

the practicability of handling the number of units and production of parasites mentioned, no difficulties are likely to be experienced in that. The regular distribution of the parasites is however a different matter; so far, even though planters have to be written to individually to send in to town during their alloted week for parasites, there are very few that fail regularly to respond, and it is considered that they would soon adopt the weekly plan without needing the present continual notification, and that they could easily handle their increased individual quota for distribution.

There would naturally be a certain number of planters who would fail to respond at all, but some method of dealing with their fields, other than by wind drift from neighbours could no doubt be found. Peasant holdings and very small estates would present a difficulty, but some liberations to these areas could be made by Departmental Staff, or by other arrangements.

If it were not possible to distribute *Trichogramma* from one easily accessible breeding station as in Barbados, there should be no difficulty in establishing smaller stations of two or more moth units and corresponding parasite breeding facilities, all under the periodic supervision of one Entomologist. The remaining requisite would be the intelligent and willing co-operation of the growers of the crop through which the parasites are to be regularly liberated.

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JAVA CACAO.

THE high position held by Java cacao in the cacao markets of the world and the importance of the variety grown on the quality of the product and its market value, have recently been the subject of an interesting article* by no less an authority than Dr. C. J. J. van Hall. The author points out that the fine quality of Java cacao is undoubtedly due to its strong Criollo characteristics. In considering the types of cacao at present grown in the various cacao-producing countries of the world, he shows how the tendency in many has been for the Criollo type, where originally grown, to be supplanted by Forastero or types that are predominantly Forastero. Where this has occurred it is noticeable that a lowering of the average or relative price of the exported beans has always resulted. Trinidad is quoted as an example where this has taken place. The author uses these arguments as a plea to planters in the Dutch East Indies to refrain from establishing trees other than those with marked Criollo characteristics if their present enviable position is to be maintained. The figures furnished of cacao prices over a period of years show how the price of Java cacao—considered always a superior or luxury grade—is generally more than double or even three times the price realized by West African and certain other grades. An additional advantage is that the price of the higher grade article is fairly stable and not subject to the ups and downs that characterise the cheaper sorts.

An account of the varieties better known to the cultivators in Java is given, which includes an account of the origin and history of the now well-known "Djati-Roenggo Hybrid". This arose as a result of hybridization of a single Forastero tree (imported by an estate manager in Java in 1888 from Venezuela as "Caracas cacao") with the true Criollo then existing in Java. Fortunately this hybrid possessed a preponderance of Criollo characters. Up to about 1900 Java cacao consisted of more or less pure Criollo, but after that date beans of a more hybrid or mixed nature began to be marketed. Reference is made in the article to the decline of interest in cacao cultivation in Java that took place with the advent of *Hevea* rubber, but it is stated that a distinct revival of interest is now noticeable.—(*Kew Bull. Misc. Inform.*, No. 8, 1931.)

* "De Herleving van de Cacaocultuur in Ned.-Indië en de Invoer van Cacao-Variëteiten uit andere Landen", Dr. C. J. J. van Hall. Berichten van de Afdeeling Handelsmuseum van de Kon. *Vereeniging Koloniaal Instituut* No. 58, p. 9 (*Druk J. H. de Bussy*, Amsterdam, 1931). Price F. O. 40.

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SISAL.

By R. W. R. Miller, B.A. (Camb.), A.I.C., Dip. Agric. (Cantab.).

Introduction.

Sisal belongs commercially to the same class of fibres as manila and jute. The fact that it has hitherto not been found possible to spin a cloth suitable for the manufacture of wearing apparel from this type of fibre is largely because there is no natural twist in the individual fibre as is the case with cotton. Nevertheless, despite its restricted application, the acreage under sisal has shown a phenomenal increase during the last decade and it may now be numbered amongst the most important fibre crops of the Empire.

Composition of Sisal Hemp from different Countries.*

	Tanganyika Territory.	*Kenya.*	*Portuguese East Africa.*	*Mexico.*
Moisture	9.4	9.7	9.3	9.0
Calculated on moisture-free material:				
Ash	0.7	1.2	0.6	1.0
Loss on a-Hydrolysis..	10.4	11.2	12.1	15.5
Loss on b-Hydrolysis..	12.9	13.2	15.2	18.4
Loss on Acid purification	2.0	2.8	3.0	6.5
Loss on Water washing	1.5	2.5	2.5	6.0
Cellulose	78.9	77.3	76.3	73.1

True sisal (*Agave rigida* var. *sisalana*) is mainly grown in Mexico, the Bahamas, East Africa, Hawaii and Java but in recent years the principal development of the crop has been, within the British Empire, in East Africa. For many years sisal was the monopoly of Mexico and Central America but early in the twentieth century it was introduced into Tanganyika Territory (formerly German East Africa), and from there spread to the neighbouring colonies of Kenya and Nyasaland.

Like the great majority of other raw materials sisal is at present suffering from a deflation of prices. Also, as the crop is almost invariably produced by large Corporations on large holdings the possibilities of reducing the cost of production are not so obvious as in certain other industries. Sisal, however, holds one great advantage in that its uses are practically unexplored as so far practically the entire world output has been converted into "binder twine" for use in harvesting grain crops.

Provided the capital value of the land is not too high, sisal will in normal times succeed economically in any tropical soil save a swamp. Like all Agaves, sisal is adapted to a zerophytic habit and can be grown successfully in arid areas. The smaller the rainfall the greater the percentage of fibre produced but the smaller the yield per acre. The quality of the fibre, however, would appear to be unaffected by the precipitation. Certain writers have stated that sisal demands an alkaline soil, but the average East African soil rarely shows more than 0.1 per cent. of Calcium Oxide and sisal produced under such conditions has maintained that uniformity of excellence which has given East African sisal a premium over that produced in other parts of the tropics.

Sisal, for various reasons, is a crop which must essentially be grown on a plantation scale. The high cost of machinery required to produce a fibre of uniform grade necessitates a large and continuous supply of leaf to produce an economic return. The leaf must also be decorticated as soon as possible after cutting, and as cattle for one reason or another do not thrive where sisal is usually grown, only mechanical transport can be used.

Sisal is a semi-permanent crop and while several tentative schemes have from time to time been put forward for small growers to send in their produce to a central factory, the organization of an economic system of transportation has hitherto prevented these schemes from coming to fruition. It is true that in certain parts of the West Indies there are a number of small estates producing sisal, but with the present prices obtaining for all fibres it is doubtful if these estates are producing economically.

With sisal at £25 per ton it is questionable whether land of a capital value of more than £3 per acre would prove an economic venture. When it is realised that machinery, building and the transportation system necessary to keep the machinery going will cost approximately £40,000, it is obvious that the production of the fibre is not for the small estate, or indeed for a collection of small estates, unless they are under the direct control of the central factory.

It may be taken then as an axiom that the minimum acreage suitable for sisal cultivation should be in the neighbourhood of 3,000 acres, so that approximately 500 acres can be planted up each year.

Choosing and Laying out the Estate.

It has already been stated that sisal will grow on practically any well-drained soil, but it should be borne in mind that the sisal plant is not being cultivated for its natural beauty but for the fibre it contains. Though little research has been attempted with this crop, much practical knowledge has been accumulated to show that a greater quantity of fibre is produced in the individual plant during the dry weather than during the wet season. When, therefore, an estate is selected for sisal production, care should be taken to ensure that whatever the annual rainfall may be, there are normally several months in the year in which the precipitation does not exceed two inches.

* *Bulletin of the Imperial Institute*, Vol. XXVII, No. 4, 1929.

In East Africa coastal plantations may give an average fibre content of 4½ per cent. while 50 miles inland the increased rainfall reduces this to approximately 3 per cent.

Compared with other agricultural enterprises in the tropics, the capital value of the machinery required for the preparation of sisal fibre is extremely high, and therefore it is a corollary that sisal land values should be proportionately low. While planters can on occasion grow coffee at a profit on land costing upwards of £50 per acre, it would appear that £3 per acre is the economic limit of value for sisal production. Added to this initial cost is the cost of clearing which may run as high as £5 though over the whole plantation it should not exceed the initial extreme limit value of the land, namely £3.

A regular all the year round water supply is essential and fortunately this is usually found in the lower parts of the estate. Instances have occurred where the unpardonable error has been committed of erecting the factory on one of the higher parts of the plantation, but the increased costs of transport of the leaves to the factory invariably cause the subsequent re-erection of the factory on a more suitable site.

As far as possible the factory site should be at the centre of the planted area as the cost of getting a regular supply of leaf to the factory will be thereby equalised all the year round and it will be easier to arrange that the same supply of leaf should reach the factory each day. The actual lay-out of the estate around the factory depends also on the acreage to be dealt with annually. A plantation with 3,600 acres of sisal would expect to be cutting 2,400 acres every year and also planting or replanting 600 acres each year. Obviously, it would be uneconomical to have the 600 acres immediately round the factory not producing leaf at all for two years out of every six or seven. The usual practice is, therefore, to split up each year's planting into blocks of approximately 100 acres so that as far as possible the total haulage of the product of the 2,400 acres being harvested at any time is the same from year to year.

Trucks are comparatively expensive and, therefore, usually limited in their numbers, and any undue congestion through a bad lay-out will be quickly reflected in a reduced output.

Labour.

At this juncture, before going into the different operations of sisal production, it is necessary to comment on the vital factor without which no plantation can possibly succeed, namely, an adequate supply of labour. Apart from the staff working in and around the factory, practically all the labour is on task work and, therefore, the greater the supply the higher the output. A sisal plantation cutting 2,500 acres of leaf per annum may employ anything between three or four thousand workers at the same time.

Now, as sisal plantations are for the most part carved out of the original bush, it follows that this labour force is not going to be immediately available. Indeed, the prevailing practice is for the local inhabitants, if any, to grow fresh food for the plantation workers who are imported from some other district.

This recruitment is usually in the hands of professional labour recruiters who charge anything up to £2 a head for their services, and who, moreover, usually only contract for the men to work for six months. Every worker, therefore, who leaves the estate on the expiration of his contract is a potential advertisement for the plantation he has worked on and in the long run the ability to secure labour, even through a recruiting agent, depends on the treatment meted out to the workers. It should be remembered that these workers are possibly hundreds of miles from their homes, with no social relaxations of their own, and the provision of adequate housing, night schools, football, sanitation and hospital, has become the custom on all well run estates.

When the recruited labour arrives on the plantation it is customary to allow them time and material to build their own houses in the style they are accustomed to rather than to herd them into ready made (and possibly much more sanitary) quarters. The average numbers in the estate hospital are usually large enough to make an appreciable addition to the cost of production and even where the local law does not require it, the provision of fresh meat and a balanced cereal ration has proved an extremely sound investment.

The foregoing may seem out of place in an article on sisal production but it is considered that more can be done to lower the cost of production by studying the labour supply than by the installation of additional machinery or altering cultural methods.

Method of Propagation.

Sisal is reproduced either by suckers, which arise from underground stems or by "bulbils" (vegetative growths which are produced in hundreds when the sisal poles (*i.e.*, flowers)). As to which method is the better is a debatable point but on the whole it may be stated with some degree of certainty that the "bulbil" will tend to produce an exactly similar plant to its parent, while the sucker may or may not. That is to say, if "bulbils" are selected from plants producing numerous strong leaves, it may be expected that the planted area will exhibit the same excellent qualities. Suckers, however, are extremely variable, as Dr. Karl Braun of the Amani Institute, found in 1908 in conducting yield experiments. Similar plants growing under exactly similar conditions gave 105, 113, 121 and 145 leaves per plant respectively and Braun also ascertained that the percentage of fibre varied from plant to plant.

On the other hand, suckers are quicker to get going and can be planted direct in the field (though this method is not recommended). In the past, too little attention has been paid to the selection of planting material, but experience has shown that, by selecting plants, even as long as two years before they pole, and after selection, not cutting

any leaves from them, "bulbils" are obtained which eventually produce sisal plants similar to their parents. In this way it is possible to increase the percentage of fibre per acre from 10 to 15 per cent.

The economic production of sisal is one long battle to reduce the cost of transport and the selection of the nursery plays no small part in these operations. The site of the nursery should be as near as possible to the area to be planted out and the proximity of a water supply is an advantage. An area of good, rich soil should be selected and thoroughly cleaned of weeds and made up into beds six feet wide. The "bulbils" are planted in eight rows nine inches apart and nine inches between the plants in each row. If the planting is made in the rains watering should be unnecessary, but the "bulbil" with no root system and only a small store of food is undoubtedly helped over a dry period by watering.

"Bulbils" usually require 12 months to develop an adequate root system, while suckers can do with six months less.

Preparation before Planting.

The optimum desideratum is the complete stumping of all timber before ploughing. With the aid of a Monkey Winch or even more substantial equipment, this can be done more economically and much more rapidly than by hand labour. Even so, the final cleaning up of all roots, scrub and bush requires to be done by hand.

In developing a sisal proposition, at least the annual unit of planting (say 600 acres) must be prepared each year, and therefore, this class of work must be carried on without cessation. Some companies favour contracting out stumping, but this practice is attended with many dangers. In the first place the work may be scamped as contractors frequently fail to keep the clearing within the time schedule and thus great losses may be caused to the company through retarded production.

Most important of all, however, is the fear that the contractor may treat his labour badly and so make the plantation unpopular and subsequently experience great difficulties in securing an adequate force of workers. It is wiser, therefore, to appoint one or more permanent supervisors of clearing. These men should be sympathetic to and popular with the workers as this work is extremely arduous and consequently difficult to get done to time.

After the roots and bush have been cleared, the land should be thoroughly disc-ploughed to a depth of 12 to 18 inches and then harrowed down to a moderately fine tilth.

The final stage of clearing should include the thorough weeding of the land and marking out with sticks of the area for the actual planting.

Distance of Planting.

The distance of planting must naturally vary with the yield of leaf per acre and on the drier areas is closer than in those parts which produce a larger crop. In East Africa, the original German practice was to plant the sisal a metre apart in the row and the same distance between the rows, thus giving 10,000 plants per hectare or approximately 4,000 per acre. It has gradually been found more economical in cleaning and cutting to plant in double narrower rows with a wider space between the double rows. In some plantations this has been extended up to a spacing of eight decimetres between plants in the row with a similar distance between the narrower rows and with 16 decimetres in the wider distance between rows. This method gives 9,600 plants per hectare or 3,840 per acre.

There is no doubt, however, that each sisal district should conduct its own spacing experiments to determine the optimum spacing for soil and district.

Planting and After-Cultivation, including Cover Crops and Inter-Cultivation.

Planting should be paid by the day as otherwise it is liable to be performed carelessly. The planter usually carries a cutlass with which he makes a hole some six inches deep in the ground and beds down firmly the rooted "bulbil" (or sucker).

Most estates allow two weedings per annum (that is about six weeks after each rainy season) for the first two years, after which time the plants have usually grown sufficiently to preclude any further work in this direction. There is, however, a growing practice of covering down the ground with bush beans or some similar crop which besides getting rid of the necessity for weeding, provide a welcome change in the diet of the labour force while the stems and leaves can then be turned in to increase the moisture-holding capacity of the soil.

On some East African estates, inter-cultivation with cotton is carried on for the first 12 months and the proceeds of the crop are looked for to pay for all weeding and cultivation between the planting of the sisal and the cutting of the leaf.

No manuring is practised with sisal cultivation beyond green dressings and considering that less than a ton of fibre is obtained annually per acre, it is extremely doubtful if artificial manuring would prove an economic proposition.

Harvesting and Transport to the Factory.

During the third or at the beginning of the fourth year after planting, the leaf is ready for cutting. The length of the leaf varies considerably with the soil and climate, but an average leaf may be taken at four to five feet. Cutters cut off the leaves from the base and care should be taken not to remove so many leaves that the vitality of the plant is impaired. The minimum number of leaves which should be left is a matter of much controversy, but the general rule is to leave not less than 15. Cutting is paid for by cubic measure, usually so much per unit of the daily task, though an experienced cutter in good sisal can cut without effort considerably more than this. For cutting a sharp knife is used and the leaves should be cut off close to the pole.

The leaves are now transported on a narrow gauge railway to the factory, the trucks being propelled either mechanically or by hand. The cost of rails renders a permanent system all over

the estate uneconomic and although in the area centred on the factory a permanent system is usually installed, special gangs are kept for laying down a temporary track over the area next to be cut. The cost of laying is negligible and reduces the capital expenditure to a considerable extent.

When the sisal leaves have reached the factory they are piled up ready for decortication and careful organisation is necessary to ensure that the leaf is not kept too long before being put through the machines. The factory manager aims at dealing with all leaf within 36 hours of its being cut as otherwise it dries out in patches and renders the separation of the fibre from the green epidermis a matter of considerable difficulty, if not of impossibility.

Decortication.

The bulky nature of the harvested leaf renders the speedy preparation of the sisal essential. Crops like flax and coffee, with their comparatively insignificant bulk compared with the area cultivated, lend themselves to more leisurely methods of treatment, but although many practical workers have endeavoured to devise schemes for the retting of sisal, the space and time required have hitherto prevented any success.

The process in practice, then, is to pass the leaves through a series of dull knives which literally tear the fibre away from the other vegetable matter of the leaf. Naturally, this is a somewhat crude and wasteful process, and it is estimated that even with the best machines there is a loss of approximately eight per cent. of the fibre.

Originally, a machine called a Raspador was used, which had the advantage of working without water, but the wastage of fibre was large and the quality not always of the best. Nowadays, large machines, such as those manufactured by Robey or the continental types (Coronas), are used. The leaves are fed continuously by a moving belt into the machine. All the exposed parts require to be made of a bronze alloy, as the acid juice exuded by the crushed leaf rapidly corrodes iron and steel. Water is pumped between the knives to clean and run off the rest of the leaf from the fibre and the fibre is ejected from the machine requiring only a momentary immersion in water prior to drying.

The drying ground takes up a considerable area immediately adjacent to the factory, and here the fibre is hung loosely on lines where it is quickly retted as it dries in the tropical sun.

Brushing and Baling.

After two or three days drying and sun-bleaching the fibre is collected and brushed. The brushes consist of revolving metal combs which quickly remove all dust, adhering vegetable matter and short fibres. It is obvious that careless brushing may prove extremely expensive and certain estates prefer to use wooden brushes. These simply consist of revolving boards (usually made of teak) and these brushes certainly produce a first grade fibre.

The shorter ends from the brushing are collected and exported as tow, while the brushed fibre is picked over by hand and divided by colour and lustre into grades, Nos. 1 and 2, and the sisal is usually exported in 400 lb. bales marked No. 1, No. 2, or Sisal Tow.

The vegetable matter separated from the fibre is dried in the sun and taken back by the empty trucks and spread over the estate. It will thus be seen that only the actual fibre (which is mainly cellulose) is removed from the land, which, with proper cultivation should maintain its productive efficiency for a considerable number of years.

Pests and Disease.

Sisal is one of the hardiest of tropical plants, and is not readily attacked by pests or disease. In certain areas a boll weevil causes losses by biting through unopened young leaves and completely spoiling the fibre. A bacterial boll rot has also been met with, though this is possibly a secondary infection subsequent to some form of mechanical injury.

Monkeys and baboons can, however, prove extremely destructive, tearing out the young hearts of the plants to an extent which must be seen to be believed and in most plantations a number of men are permanently employed in poisoning and shooting these vermin.

Poling and Replanting.

From the sixth to eighth year after planting the sisal flowers or "poles" and the plant thereafter becomes useless as a producer of fibre. Theoretically, the ground should now be stumped, freshly prepared and replanted, but in practice the poled plant is allowed to remain and the suckers which have been growing round the parent plant are cultivated and eventually cut for fibre.

This results in a shorter leaf and a shorter fibre with consequently more expensive cutting and manufacturing charges and a smaller price for the finished product. However, most plantations prefer to continue dealing with the suckers until the field becomes so uneven that it is more economic to replant.

Sisal, its Uses.

As already pointed out, the present commercial uses of sisal are entirely limited to the manufacture of binder twine for the reaping of wheat, &c. Recently, however, an attempt has been made to develop a market for marine cordage; and tests by the Imperial Institute and the Admiralty show that the breaking strain of sisal after exposure to salt water is very similar to that of rope made from manila hemp though sisal, when immersed in sea water, absorbs water more quickly than manila, swells to a greater degree and shrinks in length at a greater rate. The reports, on the whole are, however, extremely favourable, and it is anticipated that a considerable proportion of Empire grown sisal will be utilised in future years for this purpose.

The possibility of producing gunny bags from sisal should not be overlooked as for the transportation of certain classes of merchandise, sacks made from this fibre would prove just as efficient and cheaper than those made from jute.

BANANA DISEASES.

II.—Notes on "Cigar-End" (*Stachylidium theobromae* Turc.).

By C. W. Wardlaw.

Introduction.

While mature bananas in storage are subject to infection by a considerable number of semi-parasitic and saprophytic fungi (18, 19), so far, in Trinidad, only a few fungal diseases have been observed on unreaped immature fruit. The two most important of these are (i) "Cigar-End" caused by *Stachylidium theobromae*, Turc., and (ii) "Black-Tip" caused by *Helminthosporium torulosum*, Syd. Ashby comb. nov. (*Cercospora musarum*, Ashby). On both, our information is scanty. In this paper notes on some aspects of "Cigar-End" based on investigations in Trinidad will be submitted.

Other Plantation Diseases.

Apart from the two fruit rots mentioned above, diseases of immature, unreaped, banana fruits are relatively few in number. They include (i) Anthracnose, *Gloeosporium musarum* Cke. and Massee., described by Agati (1) as a parasite on green fruit in the field in the Philippines: this has not been observed in the Western Tropics. Dastur (7) in India and Park (11) in Ceylon have recorded this fungus as sometimes occurring on immature plantain fruits. (ii) Freckle, or Black-spot disease, caused by *Macrophoma musae* Cke., Berl. and Vogl. has been reported from Hawaii (5), Fiji (3, 4), and the Philippines (9, 10, 13, 14) but has not been recorded in the Caribbean region. (iii) A *Sclerotinia* disease of fruits, caused by *S. sclerotiorum* Lib. Massee (*S. libertiana*, Fuckel) has recently been described by Reichert and Hellinger (12) in Palestine. Some observations made by Tomkins (16) on a fruit-spotting disease of Cavendish bananas in cargoes from Brazil are also suggestive of a field infection, but definite information as to the pathogen is still lacking. A black-tip infection of young Cavendish fruits, accompanied by premature yellowing, has been observed by the writer in Trinidad. A species of *Fusarium* has been isolated from a number of specimens but further investigation is required.

Literature.

The disease under consideration has been recorded by Dade (6) on the Canary or Cavendish banana in the Gold Coast, by Bensuade (2) in St. Michael, Azores, and by Simmonds (15) in Queensland. A similar disease is known in Panama, the Canary Islands (8) and Madeira. There is some evidence that it has appeared in Colombia, Palestine and Mauritius* but so far no definite records have been published. It has been occasionally observed by Wardlaw and McGuire (18) in Trinidad on the Cavendish banana (Trinidad Governor) and on a variety labelled Rio de Janeiro. The organism thus appears to have an extensive geographical distribution.

External Symptoms.

Cigar-End is essentially a plantation disease, the fruits being apparently most subject to attack in their more immature stages. Sometimes only a few fruits are affected but at other times every finger in the bunch may show some disease.

The infection originates in the perianth from which it spreads slowly backwards along the finger causing a blackening of the skin, and shrinking and folding of tissues, the diseased region later becoming covered with the conidiophores and powdery grey conidia of the fungus. As these are distributed over a slightly corrugated surface the diseased end acquires a resemblance to a burnt cigar tip. If the disease is examined on young fingers at an early stage, the perianth-remains are seen to be covered with the conidiophores and conidia of *S. theobromae*, every finger of the bunch being sometimes affected according to Dade (6). The presence of the pathogen tends to make the perianths adhere persistently to the fingers and the cork layer, which is apparently imperfectly formed, does not prevent the fungus from gaining access to the fruit. To what extent external factors, such as atmospheric humidity and mechanical or insect injuries, influence the passage of the pathogen from the perianth-remains to the fruit is not yet known.

The fungus grows slowly and even in well developed specimens does not, under Trinidad conditions, cause a region of decay extending over two cm. Elsewhere more severe infections appear to be obtained. Dade (6) states that rotting may extend over one-third of the fruit, while the illustrations in Simmonds' account are indicative of fairly extensive exploitation.

Internal Symptoms.

Like the external symptoms the internal symptoms are very characteristic and are not likely to be confused with other banana fruit rots. Most of the other parasites grow actively in the fruit flesh and utilise the plentiful supplies of starch and sucrose present there. Thus *Botryodiplodia theobromae*, *Gloeosporium musarum* (18) and *Thielaviopsis paradoxa* (20) are each responsible, in varying degrees, for a break-down of the flesh into a soft watery pulp, the disease effects, at maturity, being relatively extensive. On the other hand the rotting produced by *Stachylidium theobromae* might be described as a dry rot, since the affected tissue is left in a dry, fibery condition. Furthermore, the affected region is sharply marked off from the uninvaded healthy tissue. When fruit is taken into storage, the disease makes no further progress and is not responsible for premature ripening like some of the common storage pathogens. This confirms the view that has been expressed that the infection is typical of immature fruit and apparently reaches its maximum activity while the fingers are still small and angular.

* Information by the courtesy of Mr. S. F. Ashby of the Imperial Mycological Institute.

Penetration of Tissues.

When longitudinal sections through a typical specimen of Cigar-end are examined microscopically a number of anatomical features, correlated with the external symptoms, become apparent. On passing from the healthy region below towards the infected tip it is seen that the recently penetrated sub-epidermal skin tissues undergo shrinkage as the result of fungal activity, so that the epidermis is thrown into gentle undulations (Fig. 1). Towards the distal end, where the exploitation of tissues is more marked, the epidermis is thrown into a large number of folds (Figs. 1 and 2) and in longitudinal sections is thus seen to have a highly corrugated appearance; the underlying cells are necrosed, brown in colour, and have shrunken gummy contents and involuted walls (Fig. 3). (Compare with normal tissue, Fig. 4). The vascular strands also become affected, and are found to be collapsed and undulating in outline. The epidermal cells are likewise affected; their size is diminished and they become separated from one another; the cuticle, composed of highly resistant substance, is frequently observed to be thrown into numerous minute folds over the outer walls. Here and there separate conidiophores or small clusters of conidiophores of *Stachylidium theobromae* can be seen passing out from the epidermal cells (Fig. 3). The involuted epidermis, with out-growing conidiophores as seen in longitudinal section, explains the striated or flakey external appearance of the diseased tip.

The hyphae of *S. theobromae* in the tissues both of skin and flesh are small and inconspicuous, and evidently slow growing. In the flesh, as already noted, there is apparently a sharp line of demarcation between affected and healthy tissue (Fig. 2). This is not due to the presence of any protective barrier set up by the host tissues against deeper penetration. It simply represents the limit reached by the hyphae in their slow but uniform progression from cell to cell. In the cells of the flesh, the hyphae are of small diameter but abundant, and pass freely through the cell walls. In well developed specimens of the disease the final appearance of the flesh, to the naked eye, is not unlike a dry-rot.

In the skin it has been seen that the hyphae, though somewhat less abundant, are responsible for important changes in the tissues actually invaded. In the sub-epidermal cells the presence of the fungus sometimes induced enlargement and division by transverse walls (Fig. 5). Streaks of a dark gummy substance were conspicuous in the intercellular spaces, and on the walls, but apart from the above mentioned cell-reaction there was no protection against deeper invasion by suberisation of walls or cork formation (Fig .6). In these tissues the fungus appears to be mainly intra-cellular, passing readily through the cellulose walls. The cells of epidermal and sub-epidermal tissues, though not disintegrated, are greatly shrunken and modified in the later stages of the disease (Fig. 3). It was noted that hyphae penetrate the longitudinal parenchymatous cells of the vascular strands, (Fig. 6) and are ultimately responsible for their complete collapse; at the same time the whole vascular strand, on account of the general shrinkage of surrounding tissues, is thrown into folds. As the collapsed conducting cells are unfavourable for microscopic examination it was not possible to determine to what extent the xylem had been invaded by hyphae.

On account of the great shrinkage of the sub-epidermal cells, with their brown, gummy, coagulated contents, it is difficult to follow the progress of hyphae from the inner tissues to the epidermis from which the conidiophores grow out. The latter present some features of interest. They arise from short hyphae present in the epidermal cells, but, as a rule, do not pass out directly. After passing through the outer epidermal wall a vesicle containing dense protoplasm is formed below the cuticle, so that the epidermal wall is displaced inwards A small hyphal process growing outwards from the vesicle is responsible for the mechanical penetration of the resistant cuticle. Once this has been effected the hypha again swells out sometimes into a second vesicle, and by continued upward growth, gives rise to the conidiophore (Fig. 7). The subcuticular hyphae may grow for some time before breaking through (Fig. 8). When conidiophores are being formed in large numbers the cuticle becomes displaced by the development of numerous vesicles (Fig. 9).

Inoculation Experiments.

Inoculation experiments were conducted as follows. Fingers representing a gradation in maturity, on newly emerged to half-full bunches, were inoculated in the field by placing conidia of *S. theobromae* into small incisions made at the distal end where the perianth joins the finger. The experiments were inspected at intervals of 14 days over a period of two months. Negative results were consistently obtained both during the wet and dry seasons, and so far typical examples of Cigar-end have not been obtained experimentally in Trinidad. Even when high humidity was assured by placing large tubes over inoculated fingers and plugging with cotton-wool, positive results were not forth-coming. At the same time fungological and microscopic studies leave no doubt that *S. theobromae* is the pathogen, since it can be consistently observed in and isolated from the tissues in pure culture.

As this disease is only of occasional occurrence in Trinidad the evidence, from the inoculation experiments outlined above, suggests that some relation exists between the physiological condition of the fruit and the development of infections, but further investigation is necessary before a definite opinion can be given.

The Cavendish is generally recognised to be one of the more sub-tropical varieties of banana. As this disease reaches its greatest importance in the Canaries, where an expensive hand control by picking off infected perianths is necessary, an explanation of the scanty occurrence of the disease in Trinidad and also of the failure of

inoculation experiments, may perhaps be sought in the possibility that the fungus is somewhat out of its natural environment under moist tropical conditions.

The Fungus.

The fungus can readily be obtained in pure culture by taking small pieces from the most recently penetrated tissue and planting them on any of the standard culture media. The same fungus was consistently isolated from specimens of Cigar-end and was identified at the Imperial Mycological Institute as *Stachylidium theobromae*, Turc. It will be seen from the following description of the fungus that it is in close agreement with Turconi's(17) diagnosis.*

On specimens of Cigar-end, the conidiophores which push out through the epidermis are solitary or in small scattered groups. On synthetic culture media they are produced in large numbers over the whole substratum.

The organism grows well on a variety of culture media and conidiophores are formed in the course of a few days. A detailed study of the fungus was made on sucrose media of the following compositions :—

				Medium.	*Sucrose in grammes per litre.*
Potassium phosphate	1.25	gms.	+	No. 1	5
Magnesium sulphate	0.75	do.		No. 2	10
Asparagin	2.00	do.		No. 3	25
Agar	20.00	do.		No. 4	50
Water	1,000	ccs.		No. 5	100

After three to five days on Medium No. 1 (0.5 per cent. sucrose) conidiophores were freely developed and sporulation was abundant. The conidiophores, which arise from procumbent hyphae are characteristically tapering and verticillate, and may be either long and lax (Fig. 10) or shorter and more compact (Fig. 11). They are profusely branched and at the "nodes" whorls of one to six branches were observed. The lateral branches may in turn give rise to the characteristic awl-shaped verticillate branches (Figs. 10 and 13) or, on synthetic culture media, may continue growth as vegetative branches (Figs. 13, 14). The conidiophores are septate; as a rule transverse walls appear just above the point where branches pass off; they are also frequently formed at the base of the individual branches (Figs. 12, 17). Fig. 12 shows an early stage in the development of a branch. While symmetrical verticillate branching is the rule, departures from this arrangement are not infrequent, at least on artificial media (Figs. 13, 15). The conidia are formed by successive abstrictions at the ends of the branches and may adhere together for some time. Later, they become dry and powdery, and on mounting in water as a rule only those in the course of formation remain attached (Figs. 10, 17). Spherical globules of conidia surrounded by mucous were not observed under these conditions. A large number of slender conidiophores are also formed close to the surface of the culture medium, and here the mucous globules of conidia, as described by Turconi, could be seen still attached to the branches from which they had been abstricted (Fig. 16). On Medium No. 1 the hyphae and conidia were hyaline and vacuolated (Fig. 17): older conidiophores and stout procumbent hyphae became brown after some time. The conidia measured $4 - 14\mu \times 2.5$ to 4μ.* More rounded conidia with granular contents were occasionally present.

The fungus showed a certain amount of variation according to the concentration of the culture medium. Thus on Medium No. 5 (ten per cent. sucrose) the conidia were smaller ($4 - 11\mu \times 2 - 3.5\mu$) with a larger proportion of the rounded conidia with granular contents mentioned above (Fig. 20). The latter arise from partially submerged conidiophores with dense granular and oily contents in which the whorled branches are massed together so as to give a stellate appearance when seen from above. On this medium, also, various irregularities were present in the conidiophores, and not infrequently the conidial branches continued growth as vegetative hyphae (Fig. 19). These, like most of the other hyphae were of stouter appearance than on Medium No. 1 and in response to the ample supply of carbohydrate had dense, granular and

* *Turconi's diagnosis of S. theobromae.*

"*Stachylidium theobromae* n. sp.—Conidiophoris plerunque solitariis aut laxe gregariis, rare $2 - 4$ in caespitulum congestis, erectis, $100 - 400 \times 4 - 6\mu$, septatis, cylindraceis, basi sub-incrassatis, fuligineis, sursum sensim tenuatis, pallidioribus atque verticillato-ramosis, ramis pallidioribus vel hyalinis, subulatis, apice acutatis, $3 - 5$ in quoque verticillo, rarius binis oppositis, plerunque simplicibus $20 - 30\mu$ longis, quandoque vero duplo longioribus iterumque verticillata ramulosis; conidiis in apice ramulorum capitulato-glomeratis, globulos sphaericos, muco obvolutos, translucidos, $15 - 40\mu$ diam efformantibus, dein madore diffluentibus, oblongis vel cylindraceis $4 - 6 \times 2\mu$ hyalinis

In foliis *Theobromae Cacao* socia *Physalospora Theobromae*."

* Turconi's measurement for conidia is $4 - 6 \times 2\mu$. The writer's measurements, based on a study of the fungus on different synthetic culture media, give a more extensive range, but one which includes Turconi's measurements.

oily contents. Another feature of cultures on this medium was the presence of stout filaments, with dense oily contents, which were frequently joined together in pairs by conjugation tubes (Figs. 21, 22). In older cultures several filaments joined together in this way formed conspicuous dark strands running over the surface of the medium (Fig. 23). Media Nos. 2, 3 and 4 showed vegetative and reproductive characters intermediate between those described for Media Nos. 1 and 5.

On Richard's solution agar, a concentrated medium, numerous rounded conidia with granular contents were present, while the majority of the conidia were of smaller size than those on Medium No. 1 above, measuring $4 - 8\mu \times 2 - 3\mu$. The mycelium had dense granular contents while stellate conidial clusters, from which the larger rounded conidia were formed, were abundantly present in the medium. In passing it may be noted that such sporulation was characteristic of media provided with suitable and plentiful supplies of carbohydrate. On potato blocks the conidia were also smaller than on Medium No. 1, the largest measuring $10\mu \times 3\mu$. They also showed various irregularities in shape. Fusion of hyphae by conjugation was frequent and compound filaments were present over the surface of the substratum. A conspicuous feature of cultures grown on this medium was the presence of hyphae of larger diameter with dark, swollen, terminal cells (Figs. 24, 25).

When ammonium chloride was used as the source of nitrogen in synthetic culture media, the colony as a whole (see next section) and the appearance of the mycelium in detail were profoundly modified. Staling of the colony set in after eight days and the mycelium consisted entirely of a dark, olive-green mat of procumbent hyphae. Sporulation was greatly reduced, and the relatively scanty conidiophores were more slender and less branched. Further the conidia were not of the uniform ovoid shape observed in other cultures but were definitely spherical (Fig. 26). Immature conidia were frequently of the typical ovoid shape, but various irregularities in shape were also observed (Fig. 27). The outstanding feature of this culture, however, consisted in the profuse development of hyphae composed of swollen cells like chlamydospores. In the sucrose-asparagin media described above swollen terminal and intercalary cells, with thickened walls at maturity, were characteristically present, especially in the higher sucrose concentrations (Fig. 19). In the medium under discussion, on the other hand, practically the whole mycelium consisted of cells which had become greatly enlarged. At maturity these had dense granular oily contents, and thick walls, sometimes unevenly thickened (Figs. 28, 29). They separated very rapidly and in microscopic preparations were found dispersed throughout the mounting medium just like conidia. Some of these had grown to very large size (Fig. 30), and might well be described as giant cells. Their appearance and position in the mycelium were suggestive of abnormal growth conditions, as also were the scantiness and reduced nature of the conidiophores. Sometimes such giant cells were found as part of a conidiophore (Fig. 31) and had developed in close proximity to a conidial-bearing branch. The abnormal features described above are to be attributed to the excessive acidity developed in the medium as the result of the liberation of Cl-ions on the uptake of ammonia by the fungus.

They have been described here to illustrate the extent of variation under different conditions of culture.

In *Stachylidium* the conidia are described as being hyaline while the conidiophores and other hyphae acquire a brown colouration at maturity. With regard to the latter, however, it was found that the amount of colour developed and the rate at which it appeared were closely related to the nature of the nitrogen supply. Thus, after ten days' growth when nitrogen was supplied as nitrate or peptone, the conidiophore bases were characteristically of a brown colour, whereas in corresponding asparagin media only occasional conidiophores showed brown colour at the base, while again when nitrogen was supplied as urea, sporulation was normal, but the conidiophores and hyphae were quite devoid of colour. On most media however, some colour was present in the mycelium after a sufficient lapse of time.

Growth on different Media.

Growth measurements were made on the sucrose media shown above at room temperatures (approx. 32 °C.) with the following results :—

Medium.	Colony Diameter in cms.		
	4 days.	9 days.	12 days.
No. 1—0.5 % sucrose ..	1.4	4.0	5.2
No. 5—10 % do. ..	1.6	4.2	5.7

It is evident that growth proceeds very slowly, but without staling of the colony, and increases slightly with increased sucrose concentration. The fungus also grew at approximately the same rate when the asparagin content was varied from 0.0 per cent. to 2.0 per cent., a slight retarding effect being present at higher concentrations.

By preparing a number of synthetic media it was found that the fungus could utilise carbon from a variety of sources including arabinose, glucose, galactose, sucrose, maltose, raffinose, starch, and glycerol. Where the only source of carbohydrate was cellulose the mycelium showed slightly more growth than on a medium containing no carbohydrate (other than that provided by the agar) while with mannitol as the source of carbon a moderate mycelial growth was obtained.

The character of the colony varied considerably according to the source of nitrogen provided. The fungus was grown on the following media :—

				Medium.	Source of Nitrogen.
Sucrose	.. .. ..	25.00	gms.	No. 6	..Potassium nitrate
Potassium phosphate	..	1.25	do.	No. 7	..Ammonium Chloride
Magnesium sulphate	..	0.75	do. +	No. 8	..Asparagin
Agar	.. .. ..	20.00	do.	No. 9	..Peptone
Water	.. .. ..	1,000	ccs.	No. 10	..Albumen
				No. 11	..Urea
				No. 12	..No nitrogen

The following observations were made :—

Medium.	Colony Diameter in cms.		Appearance of Colony.
	4 days.	8 days.	
No. 6	2.0	4.3	Mycelium at first white, slightly aerial, later becoming pale grey, with dark hyphae in medium.
No. 7	1.8	3.6	Whole colony dark olive-green, with undulations.
No. 8	1.8	3.9	Mycelium slightly aerial, white then pale grey, dark hyphae in medium.
No. 9	1.9	3.9	As above.
No. 10	1.9	4.3	As above, but whole colony of a darker grey colour.
No. 11	1.1	2.3	Compact white colony, with undulations raised above medium, no dark coloured hyphae present.
No. 12	1.9	4.1	Mycelium hyaline and submerged.

With the exception of Medium No. 7 (ammonium chloride) where complete staling due to excessive acidity took place on the eight day, and No. 11 (urea) where growth was slow but uniform, the other sources of nitrogen gave closely comparable growth rates ; colonies on nitrate and albumen had slightly higher growth rates than those on peptone or asparagin. Where nitrogen was supplied as ammonium chloride the culture was profoundly modified, being entirely of a dark, olive-green colour, in marked contrast to that on the urea medium where the characteristic dark hyphae in the substratum were completely absent.

Summary.

1. Cigar-end, a plantation disease of the fruits of the Cavendish banana, has a wide distribution in the tropics, and is caused by the fungus *Stachylidium theobromae*, Turc.

2. The infection originates in the perianth and spreads slowly backwards over the fruit causing a tip-rot, to which the aptly descriptive name of Cigar-end has been given.

3. Infections in Trinidad are usually inextensive, although elsewhere they may cause rotting over one-third of the finger.

4. The internal symptoms differ from those of many of the storage diseases in that the flesh does not become soft and watery but acquires a dry fibery appearance.

5. The skin tissues are very thoroughly exploited by the fungus so that the epidermis and vascular strands are thrown into characteristic undulations.

6. Inoculation experiments conducted in Trinidad during both the wet and dry seasons have consistently yielded negative results although fungological and microscopic studies leave no doubt that *S. theobromae* is the pathogen.

7. Notes on the morphology and cultural characters of the fungus are submitted.

In conclusion the writer wishes to record his indebtedness to Mr. S. F. Ashby, of the Imperial Mycological Institute for identifying the organism and supplying literature, and to Prof. H. R. Briton-Jones and Prof. E. E. Cheesman for technical facilities provided by them.

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THE SUB-SAMPLING OF BAGASSE.

The Sub-sampling of the Bagasse obtained from Cane Samples.

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I.—Introduction.

With the increased attention now being paid to the pre-harvest sampling of cane and the greater reliability of the results now being obtained from experimental plots, due to improved statistical technique, it appears necessary that the methods of sampling and analysing the cane should also be as reliable as possible. As far as the analysis is concerned, this is usually carried out according to standard methods which have been evolved by expert practical chemists. The sampling of the cane has recently received a good deal of attention (1, 2, 7) and different methods have been put forward. In order to obtain an estimate of the Pol. per cent. cane it is necessary to analyse the juice and the bagasse, and this involves the necessity of sub-sampling both these products. The sub-sampling of juice is fairly easy and straightforward, thorough mixing being all that is necessary, but the sub-sampling of the bagasse is a rather different type of problem. The chief difficulty is the inherent bulkiness of the material and the limiting factor to good mixing is the degree of sub-division which the small laboratory mill is capable of producing. The product to be handled usually takes the form of "squeezed" cane even if it has been passed two or three times through the mill, and as such some method of preparation is necessary before analysis can be carried out. Chopping machines, while not being ideal, are useful in this respect and reduce the bagasse to chips, the size of which may be varied. The purpose of this investigation was to determine a method for sub-sampling bagasse which is both rapid and accurate.

II.—Review of the Literature.

Several papers have come to notice in which the writers report their work on the sampling or analysis of bagasse from the factory mill. Scant attention, however, seems to have been paid to the sampling of bagasse from the small laboratory mill. The reason for this may be that the value of field samples has not been realized until comparatively recent years. The product of the laboratory mill, even after two or three crushings, is still a fairly coarse material and its sub-sampling therefore offers rather greater difficulties than the sub-sampling of the factory mill bagasse. V. Khainovsky(5) has evolved a method in Java for determining the Pol. per cent. on an unchopped sample, but the necessary apparatus seems to be rather large and bulky and a steam supply to the laboratory is necessary. As field sampling is also carried out before the factory starts, a laboratory boiler is indicated. The same author in another article(6) attempts to justify his method by stating that chopping takes up too much time and that the polarization is changed by inversion. Deerr(3) has also suggested a method whereby the whole of the sample can be utilized but states that chopping can be eliminated because modern mills produce a material in the necessary fine state of division. This method is therefore of little use in solving the problem under discussion.

III.—Experimental.

Four methods were tested, one against the other; and three series of these tests were carried out. The four methods were as follows:—

Method No. 1.—The bagasse was divided into eight portions, as near as possible equal to one another. Each of the portions was then chopped separately and a 50 gram sub-sample used for the Pol. determination.

Method No. 2.—Each piece of the bagasse was torn longitudinally into two and each of the halves was put on to a separate heap. Each of the heaps was then subdivided into four and each of the quarters was chopped separately, a 50 gram sub-sample being used for the Pol. determination.

Method No. 3.—All the bagasse from the cane sample was chopped up, the chips thoroughly mixed and divided into eight parts. A 50 gram sub-sample from each of these eight parts was used for the Pol. determination.

Method No. 4.—Each piece of the bagasse was torn longitudinally into two and each of the halves was placed on a separate heap. Each of the two heaps was then chopped separately, mixed thoroughly and divided into four parts thus yielding eight heaps. A 50 gram sub-sample from each of the heaps was used for the Pol. determination.

It can be seen that each of the series of tests consisted of $4 \times 8 = 32$ Pol. determinations, samples Nos. 1-8 being obtained by Method No. 1, Nos. 9-16 by Method No. 2 and so on. Each of the methods was designed with the idea of yielding data so that one of them could be chosen as a reasonably rapid, convenient and accurate method for use in the laboratory.

IV.—Results.

The Pol. per cent. bagasse was determined on each of the ninety-six sub-samples by the method of single digestion of 50 grams.

The results of each of the methods of sampling the bagasse were then tabulated, the mean and deviation of each of the sub-samples from this mean calculated together with the variance and standard error. It was then necessary to test the significance of the difference of the means of each of the four methods tested. This was carried out according to Fisher (4). Table 1 sets out the results :—

Table No. 1.

	(D. F.) Degrees of Freedom.	Standard Error. (S. E.)	S. E. per cent. Mean.	$\log_e$ S. E.	Z=Diff of Logs.		P=.05	P=.01
(1) Method No. 1 ..	23	.76	8.17	2.0285	(1)-(2)	.2878	.3425	—
(2) Method No. 2 ..	23	.57	5.76	1.7407	(1)-(3)	.6933	.3425	.4890
(3) Method No. 3 ..	23	.38	4.10	1.3352	(1)-(4)	.3796	.3425	—
(4) Method No. 4 ..	23	.52	5.71	1.6489	(2)-(3)	.4055	.3425	—
					(2)-(4)	.0918	—	—
					(4)-(3)	.3137	—	—

When the value for "P" is less than the value found for "Z" then the difference is significant. With P=0.5, the chances are 1 in 20 that the difference is going to be exceeded by chance and for P=.01, the chances are 1 in 100. The difference between the means of methods 1 and 3 is therefore very definitely significant, the differences between the means of methods Nos. 1 and 4, and 2 and 3 are reasonably so but the difference between the means of methods 1 and 2 is not significant.

These deductions may be tabulated as follows :—

Table No. 2.

Method No.	1.	2.	3.	4.
1. ..	—	—	—	—
2. ..	N.S.	—	—	—
3. ..	S.	S.	—	—
4. ..	S.	N.S.	N.S.	—

"S" denotes difference of means is significant.
"N.S." do. do not do.

V.—Discussion.

From the "significance" results set out in Table 2 and the standard errors as set out in Table 1, methods Nos. 3 and 4 yield significantly the same result, of these two methods, No. 4 necessitates chopping up only half of the bagasse and is therefore superior to method No. 3 on the grounds of greater rapidity. Taking into account both rapidity and accuracy, it seems that method No. 4 is the one most suited to laboratory use.

VI.—Summary.

1. Four methods of sub-sampling bagasse have been tested out under identical conditions.

2. The method designated as No. 4 appears to be the most satisfactory from the viewpoint of both accuracy and rapidity.

VII.—Acknowledgments.

The author wishes to thank Mr. G. Carr, Bench Chemist of this Department, for the part played in carrying out the analyses and Mr. W. Scott, Chief Chemist of Usine Ste. Madeleine, for the interest shown in this work.

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TRINIDAD PLANT DISEASES.

Notes on some Diseases of Main Crops in Trinidad.

By H. R. Briton-Jones.

Cocoa.

Black Pod and Canker.

As in the past the disease which causes most damage to the crop at the present time is Black Pod and Canker (*Phytophthora palmivora*) (P. Faberi). Spraying with 4-4-50 Bordeaux has apparently (5) given good results against this disease but several cocoa planters are agreed that it is not possible to carry out an annual spraying programme in the manner recommended because of difficulties in the labour supply. In a good many cocoa estates on undulating or hilly land, spraying is also ruled out on account of various other practical difficulties. Reduction of shade and of heavy overhead canopy are also recognised means of reducing Black Pod and Canker. As Canker is one of the main factors which limits the age to which cocoa trees live on account of its partial or complete ringing of the stems it is evident that there is a great deal of further investigational work to be done on this disease. As has been described by Nowell(5) shade requirements in cocoa depends on local conditions and no generalisation is possible. It varies markedly between one field and another on the same estate. The two most hopeful lines of work are (i) pruning including method, time, and degree, (ii) amelioration of soil conditions which are essential for upkeep of yield and make possible reduction of shade and therefore reduction of Black Pod and Canker. The effect of good drainage and windbreaks is well known. The limiting of the age of the trees by Canker is to a great extent the cause of the growth of one or more chupons at the bases of the old and damaged trunks. It is the common practice in plantations to allow one or more of these chupons to grow so that the best one can be selected later to replace the present tree. On the best estates, however, special nurseries are grown for this purpose the seed for which has been selected from known heavy bearers. It is a point of interest to consider how much heavy bearing has to do with resistance to Canker. It is noteworthy that most of the heavy bearers are large and old trees. This in no way detracts from the importance of other genetic factors which influence bearing capacity.

Root Disease. (*Rosellinia* spps.)

Root disease occurs in patches on several estates in Trinidad but is by no means general in its occurrence. The methods of combating the disease are well known to planters and the majority take prompt action.

Witch Broom Disease. (*Marasmius perniciosus.*)

This disease is now recognised as a serious menace to the cocoa industry, and is spreading over most of the island except the Northern Range. The method of control at present is by means of a thorough system of inspection by Officers of the Department of Agriculture and the cutting out and burying or burning of the affected parts. With a view to improving methods for controlling this disease further research work on the relationship of host and parasite has been carried out. The results of this investigation have recently been published in this Journal(6).

Coconut Palm.

Bronze Leaf Wilt.

That coconuts have been planted on much land which is unsuitable is shown by the fact that in the majority of cases they take 12 to 15 years to come into bearing. Thousands of coconut palms die annually between the ages of 12 and 20 years. The affection is not confined to palms between these ages since unmistakable signs of future trouble can be seen in palms several years before they come into bearing. Further, when conditions of growth are not so unsuitable the palms die at an older age than 25 years. The malady is caused by a combination of factors on unsuitable soil including drought, unsuitable or injurious cultural practices, and too close planting.

Red Ring. (*Aphelenchus coccophilus.*)

There are two methods of establishing a coconut plantation in Trinidad, namely, in sugar-cane and on land which has not for some years previously been under cultivation of any kind. The incidence of Red Ring in coconuts established in sugar-cane cannot be considered a disease of prime importance. In uncultivated land, however, the disease causes much damage and although isolation, burning diseased plants, and drainage lessens the intensity of the attacks somewhat, such measures cannot be considered even by the most optimistic to be adequate. The marked difference between the amount of disease under the two systems referred to suggests interesting lines of work. Cultivation of sugar-cane improves conditions of growth generally speaking and inevitably changes these conditions to such an extent that it brings about corresponding changes in the botanical flora. The improvement of soil conditions under cultivation is not stressed as such in relation to Red Ring since in some cases palms thrive much better on lands which have not been cultivated for many years as compared with palms on cultivated sugar lands. The explanation is, therefore, probably something other than the effect of cultivation on the condition of the coconut palm. A possibility is that cultivation and growing of sugar-cane eliminates the growth of a weed which might be an alternative host plant to *Aphelenchus coccophilus*. Large areas are planted in coconuts and so much loss is caused by Bronze Leaf Wilt at the present time and inevitable in the future that it presents one of the main and most difficult agricultural problems in the colony.

Phytophthora Bud Rot. (*P. palmivora.*)

This cannot be considered a serious disease in Trinidad but it occurs to some extent in most of the larger plantations and occasionally in small groups of palms. On the larger plantations it generally escapes detection until it is well advanced. This is due to the fact that the palms are so closely planted that the leaves of adjoining trees overlap thus forming a heavy canopy which

effectively hides from view the central column which is affected. The disease together with the boring beetles which are attracted to the rotting tissue often kill the palm. On the other hand recovery is not by any means infrequent with the result that the palm develops a condition known as "Little Leaf". This was previously considered to be a specific disease. "Little Leaf" is treated by the application of disinfectants to the crown and by cutting the strainers. Cutting the strainers to relieve pressure and a dressing of manure to stimulate growth are probably more important than the application of disinfectants.

Sugar-Cane.

Mosaic.

Close co-operation between the Officers of the Department of Agriculture and planters in an energetic and thorough system of inspection and rogueing of diseased plants has effectively kept this disease under satisfactory control in recent years.

Root Disease.

As in other countries several fungi have been found associated with Root diseases in the West Indies as a whole and a clearing up of this complex as the result of further research work might give results of considerable practical importance. For instance, how far do inconspicuous root invading fungi influence (1) ratooning capacity, (2) tillering, (3) optimum interval of planting, (4) froghopper damage, (5) a fundamental factor in cane breeding for special localities.

Citrus.

Wither-Tip (*Gleosporium limetticolum*) of Lime Trees.

This disease is general in the island with the result that the growing of the West Indian lime has received a serious check. On the other hand, the fact remains that in the few plantations left good crops of limes are produced in spite of this disease. The writer is convinced that the West Indian lime industry could be increased three or four fold in spite of Wither-Tip disease. In some years losses will be considerable and this is entirely dependent on weather conditions. If Wither-Tip were considered in terms of good and bad weather conditions instead of a menacing disease with unlimited possibilities there is no doubt that much could be done to increase or at any rate retain for the British West Indies an established market for the West Indian lime until such time as the resistant or immune variety of Lime with other desirable qualities is produced. A point worthy of investigation is the observation that lime trees growing in the shade of leguminous trees (*Glyricidia*) are less affected by Wither-Tip than those under non-leguminous trees.

A further interesting point about "Wither-Tip" is as follows:—In a report on his visit to St. Lucia in March, 1927, the writer suggested the possibility of irrigation in the dry season resulting in earlier flowering and fruit setting of the West Indian lime, thereby lessening to an appreciable extent the damage caused by the Blossom Blight and Fruit spotting phases of the disease. This has since been tried in the Souffriere District of St. Lucia with marked beneficial results.

Root Disease and Gummosis.

Grapefruit has been in recent years and is at the present time being planted in several localities with a view to establishing a grapefruit industry. One or more forms of Gummosis have been observed in groves of fruiting age. There are the following possible reasons for the outbreak of Gummosis on young cropping grapefruit trees (i) that the stock is not sour-orange but another variety which bears fruit somewhat similar in appearance to sour-orange; (ii) there is a limit to the resistance of even sour orange stock to some forms of Gummosis and it would be prudent carefully to select land suitable for citrus growing before planting; (iii) the union of stock and scion is too near the ground. The writer finds no reason for modifying his previous recommendation (1) to work all citrus trees at a height of 12 to 18 inches above ground level.

Scab. (*Cladosporium citri.*)

Young plants of sour-orange which are being raised as stocks for other citrus fruits are severely attacked by scab in several parts of the island. The disease does not kill the young plants but markedly checks their growth thereby increasing the age at which they become workable as stocks. The time factor is important in the nursery since the cost of weeding and cultivation of the young stock beds adds to the cost of production of the budded trees. The following two points are of interest in regard to scab in Trinidad:—

(i) in Florida scab disease causes much damage to grapefruit, whilst in Trinidad, grapefruit (var. Marsh) worked on sour-orange stock comes away quite free of the disease.

(ii) in the one locality of the Aripo Valley where sour-orange is grown for nursery work the disease occurs to such a slight extent that it ceases to be of any importance. In consequence, growth is much more rapid and budded trees of better quality can be produced at less cost.

No explanation of the above two observations can at present be given with any degree of certainty. In regard to grapefruit the explanation may be due to the fact that the variety of grapefruit is different and that they differ in susceptibility. On the other hand, the fungi may be biological species of *Cladosporium citri.* In regard to the regional distribution of Scab on sour-orange stocks in Trinidad the explanation may be forthcoming when meteorological data are kept in the different localities and compared with the following findings by Pellier and Frederick (3):—

"The three essentials for successful infection of citrus plants by *Cladosporium citri*, under controlled conditions, are the presence of free moisture, young growth, and temperature between 15° and 23.5°C (59° and 74.3°F). The optimum for the best development of Scab appears to be about 20° to 21°C (68° to 70°F)."

Coffee.

Coffee is a crop which has probably greater possibilities in at least three West Indian Islands (viz. :—Trinidad, St. Lucia and Dominica) than is at present realised.

BROWN EYE SPOT. (*Cercospora coffeicola.*)

This disease occurs on Arabian coffee in Trinidad but not to any serious extent either on the leaves or the berries. This is due to the fact that Arabian coffee is grown as topped bushes interplanted in cocoa and, therefore, adequately shaded to suit local conditions. Reduction of shade is advocated by some but in the main, soils in Trinidad coffee-growing areas are neither sufficiently rich nor of the texture to allow of this. The question of control does not arise at the present time but the following quotation from Nowell(5) fully covers it :—"Although the disease is not entirely dependent on poor condition of the trees it is most prevalent where shade is insufficient, where the soil is poor or where cultivation and manuring are neglected."

VIRUELA, AMERICAN LEAF DISEASE. (*Omphalia flavida.*)

This disease has developed to such a serious extent on Arabian coffee in the Northern Range that its control has been the subject of a special investigation. The writer has recently published(2) an account of his work which shows that the disease can be effectively and economically controlled by a system of pruning and defoliation. The disease is not serious except in the higher valleys which, incidentally, are recognised as being the best localities for growing this crop. Disease in Arabian coffee need not be considered a serious difficulty in Trinidad under present conditions of growth. The disease also affects Robusta coffee.

SCLEROTIUM DISEASE. (*Sclerotium coffeicolum.*)

This disease occurs on both Liberian and Excelsa coffee in the south of the island where these varieties are grown. It does not, however, cause very serious damage. On the other hand, in the North-West District of British Guiana it causes much damage particularly in some years. Martyn (4) who has studied the disease in British Guiana has shown that the degree of attack is dependent to a large extent on weather conditions in the second dry season in the years when the rainfall is high. These findings by Martyn indicate the necessity for small trials of these varieties in other parts of Trinidad if and when the growing of these varieties is contemplated.

Under existing conditions Arabian coffee appears to be the variety best suited for Trinidad.

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BIOLOGICAL CONTROL.

Preliminary Report on an Investigation into the Biological Control of West Indian Insect Pests.*

THE possibility of the control of the insect foes of agricultural plants by the exploitation of their natural enemies is a matter which is attracting increasing attention, and is a topic which is already familiar to tropical agriculturists. The phenomenal success which this method has attained in a number of cases and the economy of expenditure with which such success may often be accomplished, most certainly justifies a thorough examination of the possibility of employing biological control to the full. Part of the scientific work assisted by the Empire Marketing Board includes such an investigation in the British Colonies of the American tropics, and in the volume before us, Dr. Myers, who is responsible for the survey, has presented a most useful and promising account of the first part of his investigations.

With such a wide variety of insect pests as is to be encountered in the British West Indies, the author was compelled to limit his studies to the most important ones, and even then, the list of insects which are receiving attention is a formidable one, and includes some 17 species, in addition to insects of minor importance which received incidental attention. Since every noteworthy case of successful biological control has been the result of introducing foreign parasites or predators into the infested territory, the possibilities of this method are studied before considering the chances of artificially fostering indigenous parasites.

Dr. Myers' investigation is pre-eminently ecological in outlook. The plant association, rather than meteorological data, is taken as the index to the environment. The report gives general ecological notes on the localities visited and the very real bearing of this aspect on the problems of the agriculturist is amply justified. The resulting studies, which have involved a considerable amount of original work on plant ecology, have indicated two theoretical considerations which will probably prove to be of prime importance in future biological control work.

* J. G. Myers, SC.D., F.E.S. *E.M.B.* 42. pp. 172 2 maps. London, *H. M. Stationery Office*, price, 1s. net. July, 1931.

The first is that it is incorrect to say that the greatest hopes of biological control will refer to islands and not to continental areas. The author shows that the range of an agricultural plant species in a tropical continental area, is strictly bounded by ecological barriers, which circumscribe that range quite as effectively as any sea barrier could do, from the point of view of the insects included in its fauna. For the purposes of biological control, therefore, considerable tropical continental areas may prove to be as suitable as islands for the reception of introduced natural enemies. In the second place, the original wild habitat is to be considered not only as the most promising source of efficient parasites, but also as offering a clue to the causes of the present pest status of the insect in its adopted agricultural habitat.

The specific insect problems studied by the author include the following, amongst many others. Those mentioned here are either insects for which promising remedial measures are recommended or those which are of extreme importance to agriculturists at the present time.

1. Moth-borers of sugar-cane (*Diatraea* spp.). Of this large genus, at least four species are shown to be of economic significance in the British West Indies and British Guiana. There are other species of economic importance in the non-British colonies and non-economic species occur as pests of weeds in the British islands. These are all of importance, as they are potential pests of cultivation and since they also serve as hosts for parasites and predators which may or may not attack the species which are attacking cultivation in our own colonies. The natural habitat of the *Diatraea* species is unknown; ecological considerations would seem to show that their rise as pests of cultivation has been different in the case of each species. Certainly their economic status in the different colonies varies. Thus *D. impersonatella* is the most injurious species in Trinidad, but scarcely ever attacks cane in British Guiana. A scheme of detailed research into these pests on lines laid down by Dr. Myers has now been put into operation in British Guiana and Antigua, but enough has already been learned to justify certain recommendations. The only effective *Diatraea* parasites known are the flies *Lixophaga diatraeae* and *Paratheresia claripalpis*. The former should be suitable for introduction into certain of the Lesser Antilles and a consignment has already been sent to Barbados, which may serve as a centre for later introductions into other localities. *Paratheresia* may perhaps be introduced with advantage to Berbice and the western side of St. Lucia. Other parasites for introduction into the remaining localities are to be sought on the mainland.

2. Studies on the large borer of sugar-cane (*Castnia licoides*) were facilitated by the discovery of the insect in quantity in its hitherto unrecognised wild host (*Heliconia bihai*) by Mrs. Myers. Further investigation of this material led to the discovery of a promising Tachinid parasite which it is proposed to introduce into Trinidad.

3. The cane root-borer (*Diaprepes abbreviatus*) and its allies are apparently of Antillean origin. No parasites of the borer are known, and as a pest, it is still increasing in importance in Barbados. An egg parasite of a closely allied genus, however, is known from Haiti, and this actually parasitises another species of *Diaprepes* in Montserrat. A misprint occurs on p. 116 line 12, where the percentage of parasitism by *Tetrastichus* is given as six per cent., whereas it should, as Dr. Myers informs me, be 64 per cent. It thus seems possible that a successful introduction of the parasite into Barbados might be made.

4. Work on the sugar-cane froghopper (*Tomaspis saccharina*) in Trinidad is in the hands of the specialist staff of the Sugar-Cane Investigation Committee. The froghopper parasite *Carabunia* discovered by Dr. Myers in Cuba, which was at first considered a promising parasite for introduction into Trinidad, has been found to have highly specialised host relations and will not parasitise froghoppers of the genus *Tomaspis*. The search for other froghopper parasites in South America has been commenced.

5. The cacao thrips (*Heliothrips rubrocinctus*) has been shown not to be a pest of wild cacao in its native habitat, but is essentially a pest of cultivations, in which its relations with the host plant would seem to be highly complex. There is a strong suggestion that the guava is the original host plant. American parasites and predators of this pest are extremely scarce and the possibility of introducing an efficient egg parasite from the Gold Coast is suggested.

6. The cacao beetle (*Steirastoma depressum*), like the preceding, is only a pest of cultivation. A number of parasites have been discovered, but these are not sufficiently dominant to keep the beetle in permanent control. It is suggested that a suitable parasite might be found in Ecuador, where the cacao, grown under semi-wild conditions, suffers little damage from this beetle.

7. The pink bollworm of cotton (*Platyedra gossypiella*) is a recent introduction into the West Indies and its distribution presents many curious features. Not the least of these is the sudden drop in infestation which occurred in Montserrat during the 1929 season, and the immunity of the native Haitian cottons. Two introductions of a parasite from the Sudan have been made, but for various reasons, both failed to establish. If the present low rate of infestation continues, no further introductions will be required, and in any event, it is likely that a parasite already occurring in Trinidad will prove to be more efficient.

8. Cotton stainers (*Dysdercus* spp.) occur on various hosts throughout the West Indies, but the rate of parasitism is negligible. Both predators and parasites of these insects are known in Africa where, according to Ritchie, the stainers seem to be significantly less abundant. Introductions of natural enemies from Africa or from Queensland may be contemplated at a later date.

9. The green bug (*Nezara viridula*) is a serious pest of cotton in some islands and is even more serious on some of the vegetable crops which have

recently been encouraged as the basis of a new export trade. In the colonies where the pest is not serious (*e.g.*: Trinidad and British Guiana), no parasites were found. Egg parasites are said to be highly efficient in St. Vincent and a heavy parasitism is recorded from Florida. It is hoped that further study on the mainland will bring other efficient enemies to light.

10. Mahogany shoot borers (*Hypsipyla* spp.) constitute the most serious pests of timber trees in the West Indies, particularly of trees under plantation conditions. At least five parasites have been discovered by Dr. Myers, but the rate of parasitism is low and the problem demands more intensive study.

In addition to the above pest insects, many others have received considerable attention and suggestions for the biological control of several of these have been made. It is earnestly to be hoped that further continuation of this work will be possible, so that the many promising projects may be brought to a successful conclusion.

A. P.

THE COLLEGE.

[*The following is the gist of a speech made by the Principal when he was entertained to dinner by the West Indian Club in London on 3rd September*, 1931.]

Mr. Evans began his address by expressing his appreciation of the generous way in which the College had been treated by the West Indian Colonies. Its functions were essentially those of training and research and its policy was not to attempt more than it could manage, but to make a thorough job of what it undertook. More recently also, an Advisory Department had been created which had taken over the duties formerly carried out by the Imperial Department of Agriculture for the West Indies.

The College was now recognised as the main centre for training the whole of the recruits required for the Colonial Agricultural Services in the tropics, and supplied about 25 trained men a year. The career thus opened up was now attracting a most useful type of recruit from the universities. At present, sugar technology, owing to the depression in the industry, was not attracting many students, but it was hoped that this was only temporary. Admission to the College was not restricted to the British Empire, as foreigners were admitted provided they had the necessary educational qualifications, a thorough knowledge of the English language, and other satisfactory credentials. Thus, two students had been entered this year from Colombia, one from Cuba, one from Martinique and another from Siam. The admission of such students should help to spread British influence and develop mutually advantageous relations.

The College had mainly confined its research programme to sugar, bananas, cocoa and citrus—all West Indian staples. Although, naturally, the results which were being obtained were directly applicable to the West Indies, the methods evolved and the general conclusions arrived at were in many cases applicable also to other parts of the tropics.

This had been the case, for instance, in connection with the froghopper investigation, which had developed far beyond the original idea. Its soil survey technique was now being adopted in other countries, and the investigation had compelled people to tackle insect problems from a different aspect. The fertilizer experiments had now reached a most interesting stage and as a result of the recent Sugar Research Conference, it seemed likely that the Empire Marketing Board would supply the necessary fund to continue them. The value of the researches of the Economics Department had been widely recognised, and the men whom that Department was training were in great request in the Colonies, as it was recognised that the training which they were receiving was on very sound and practical lines. So far their economic researches had mainly been confined to sugar and cocoa.

With regard to cocoa, it appeared that it had too long been treated as a forest crop, whereas it should be considered as an orchard crop. Orchard methods would not prove economically possible unless the yield per tree could be raised. The first essential would be to provide the planter with really good planting materials—a vital factor in perennial crops of this description. The problem was being tackled by three scientific officers, and enquiries were being made into physiological and soil factors. The question of vegetative methods of propagation was also receiving very close attention.

The work on citrus was chiefly concerned with root stocks. Limes must be treated as an orchard crop, and not as a bush crop. Better material must be used for planting. The banana work was proceeding steadily and surely. A unique collection of varieties had been made, and new hybrids raised.

More land was badly needed for all these crops and the stage had now been reached when new types had been evolved which needed to be planted out on permanent sites, and unless funds for more land were soon made available, the progress of the research would be badly hampered.

The Advisory Department of the College had done most useful work in developing the new trade in fruit and vegetables which the West Indies were building up with Canada. In connection with this industry, four refrigerating stations had been established in the islands within the last few years.

Speaking of the present demand for economy, Mr. Evans expressed the hope that there would be no interference with the scientific work of the College.

SUGAR-CANE BORERS.

PLATE 9. *Section of parasitised eggs in position on cane stalk.*

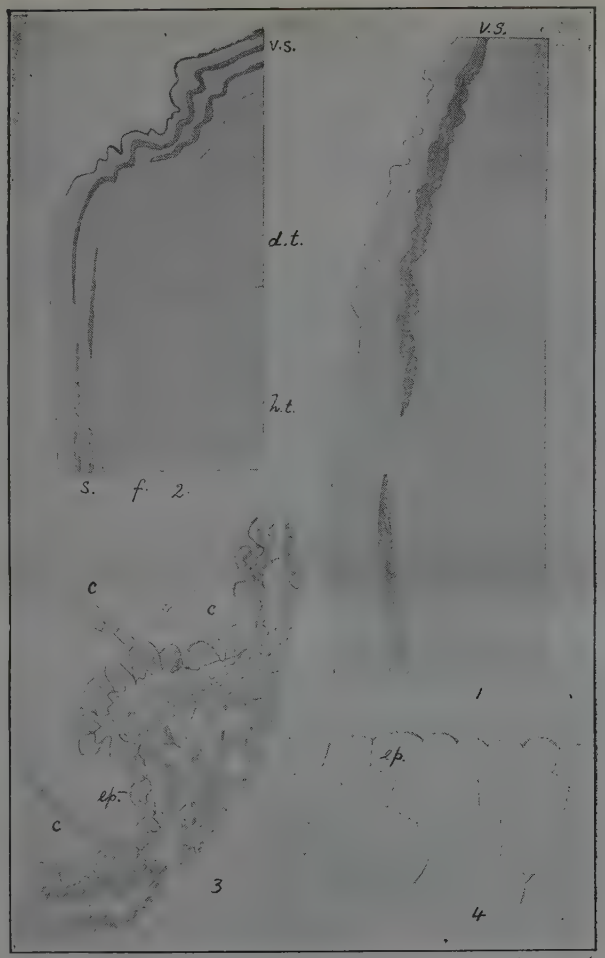


FIG. 1.—*Longitudinal section through diseased finger-tip showing the superficial tissues and vascular strand (v.s.) thrown into undulations.* (x6.) FIG. 2.—*Longitudinal section through diseased finger-tip showing the extent of the infection (d.t.—diseased tissue; h.t. healthy tissue), and the shrunken and folded superficial tissues (s.—skin; f.—flesh).* (x 6.) FIG. 3.—*Detailed drawing showing the shrinkage and involution of superficial tissues (ep.—epidermis; c.—conidiophores).* (x375.) FIG. 4.—*Normal uninfected tissue for comparison with Fig 3.* (x375.)

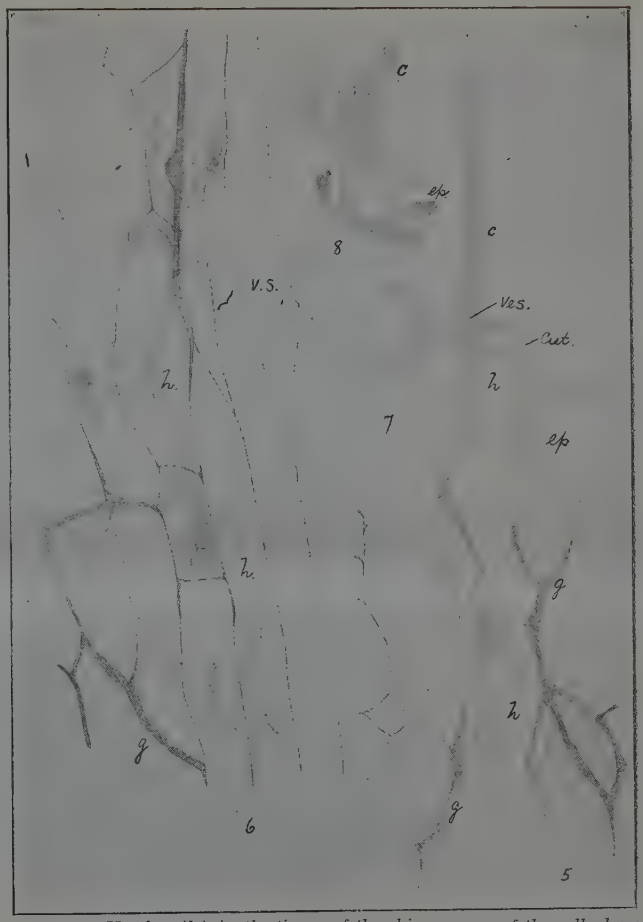


FIG. 5.—*Hyphae (h.) in the tissue of the skin; some of the cells have undergone transverse division, and a dark, gummy substance (g) has been deposited on the walls and in the intercellular spaces.* (x375.) FIG. 6.—*Hyphae (h.) in the vascular strands (v.s.) and parenchyma of the skin; g.—gummy depositions on walls.* (x375.) FIGS. 7 and 8.—*Passage of conidiophores (c.) out from the epidermal cells (ep.).* (*Ves.—subcuticular vesicle; h.—hypha; cut.—cuticle*). (x1100.)

BANANA DISEASES.

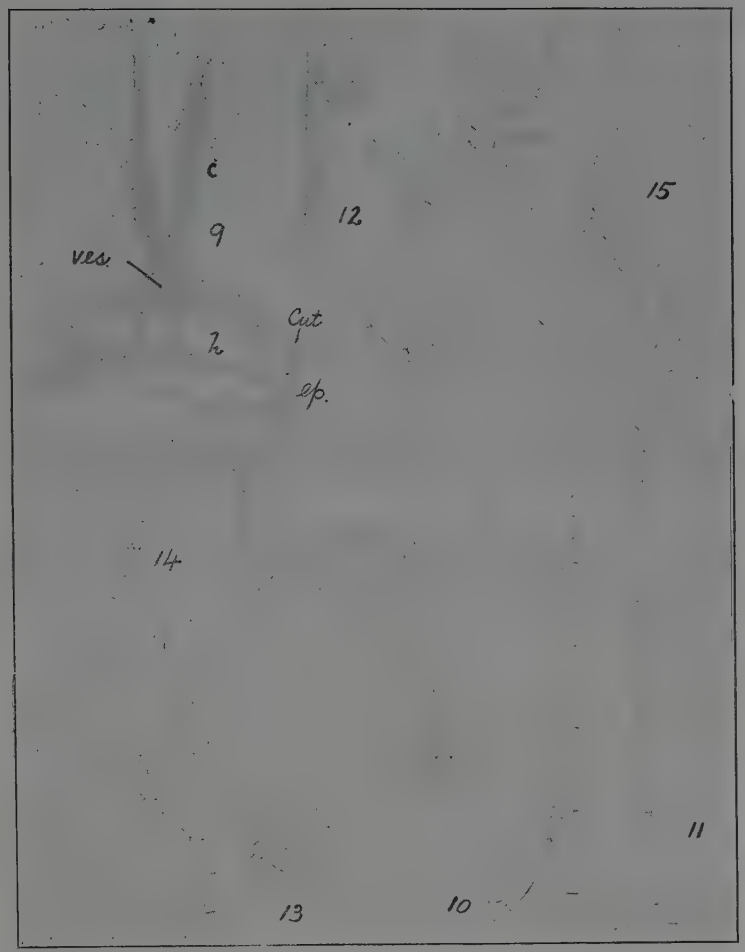
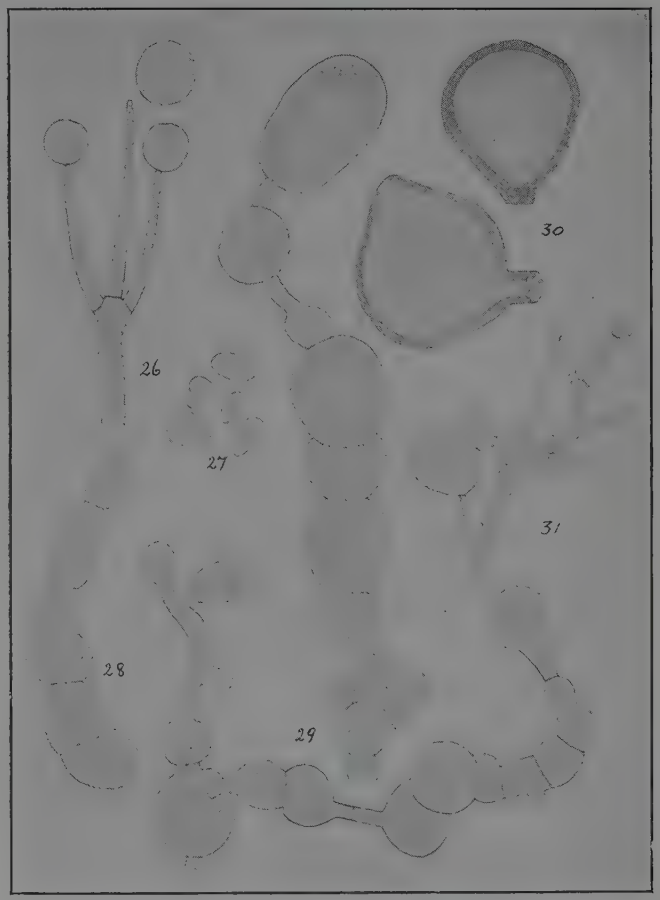


FIG. 9.—*Passage of conidiophores (c.) out from the epidermis (ep.) : h.—hypha in epidermal cell; ves.—subcuticular vesicle; cut.—cuticle.* (x1460.) FIGS. 10 and 11.—*Conidiophores of "Stachylidium theobromae" Turc.* (x500.) FIG. 12.—*Origin of a branch below a septum.* (x500.) FIGS. 13, 14 and 15.—*Irregular developments of conidiophores.* (x500.)



FIGS. 26 to 31.—*Abnormal developments obtained when the fungus was grown on a synthetic medium in which nitrogen was supplied as ammonium chloride.* (*See text.*) FIG. 26.—*Conidiophore with spherical conidia.* (x1100.) FIG. 27.—*Abnormal and normal conidia.* (x1100.) FIGS. 28 and 29.—*Characteristic swollen cells of procumbent mycelium.* (x1100.) FIG. 30.—*Giant cells.* (x1100.) FIG. 31.—*Abnormal development of conidiophore* (x650.)

BANANA DISEASES.

FIG. 16.—*Globular masses of conidia held together by mucous round the conidiophore branches.* (x500.) FIG. 17.—*Formation of conidia on the whorled conidiophore branches.* (x1460.) FIG. 18.—*Conidia from a dilute sucrose medium* (x1460.) FIG. 19.—*Irregular conidiophore development on a concentrated sucrose medium.* (x500.) FIG. 20.—*Smaller conidia from a concentrated sucrose medium.* (x1460.) FIGS. 21 and 22.—*Conjugation between filaments with dense oily contents.* (x1460.) FIG. 23.—*Conjugating filaments massed together forming a stout strand.* (x1460.) FIGS. 24 and 25.—*Large swollen, dark-coloured terminal cells of procumbent hyphae developed on some media.* (x1460)

TROPICAL WORLD NOTES.

Ceylon.

Last year, for the first time, Ceylon's three principal products—tea, rubber and coconuts—declined in price simultaneously. The total exports of tea from Ceylon in 1930 showed a decline of just over 10,000,000 lb. compared with 1929, the local average price for the year being 75 cents. Not since 1921, when the average was 70 cents, has such a low figure been reached. Between 1923 and 1927 it varied between 1.04 rupee and 94 cents. The fact that the price did not fall to a lower level is partly attributable to the effect of the restriction which curtailed the supplies of inferior teas and thus raised the average. Had not the Ceylon tea market been thus fairly well maintained, 1930 would be remembered as the most difficult and adverse period which Ceylon had been called upon to face within the memory of the present generation. With regard to the distribution of tea last year, the fall was spread fairly evenly over most of the important markets. In order to provide funds for the Tea Research Institute, the tea cess was increased from 10 cents to 14 cents per 100 lb., from January, 1, 1931, as a temporary measure. Although it is fairly widely admitted among those interested in Ceylon tea that the restriction scheme agreed to early in 1930 saved the island from even worse depression than actually occurred, the general feeling of the planters now is in favour of adopting a scheme of advertising and of seeking new outlets rather than embarking on any fresh plan of limitation. Meanwhile the Tea Research Institute has been pursuing its investigations into such matters as improvement of soil, control of insect pests, pruning and manufacture. It is generally admitted that, already the industry is one of the most efficiently organised and progressive in the world.

The Estates Products Committee has continued to study means for reducing costs of production, importance still being attached in this connection to the introduction of some process of rejuvenation on the old estates through which the low-yielding trees would be replaced by higher yielding trees, thus raising the average return over the whole area. Many estates have been importing quantities of budwood for this purpose. The Committee has also made progress with its scheme for the systematic study of coconut cultivation, including methods of preventing the spread of the coconut beetle. Although exports of coconut kernel products receded as a whole, an advance was shown in the quantity of desiccated coconut and coconuts shipped.

The prices realized for rubber towards the end of last year had fallen so low that for the majority of estates in Ceylon it barely covered the cost of production. The level to which it has since fallen is, it is feared, below the cost of production in the island generally.

The native inhabitants of Ceylon have benefited by the fall in the world price of rice. Although about one-quarter of the cultivable area of Ceylon is under rice, the island produces only about one-third of its requirements and, consequently, has to import a large quantity. A committee to assist the paddy industry has been appointed with the object, not only of improving irrigation, transport and marketing facilities, but also of supplying seed and fertilizers. It is believed that certain districts of Ceylon are well suited to some varieties of grapefruit. Hopes are entertained of finding a market in India and also of provisioning the Australian and Far Eastern steamers on their outward and homeward journeys. The possibilities of growing mangoes, oranges and plantains for export are also being discussed.

* * *

India.

In the presidential address delivered to the agricultural section at the seventeenth meeting of the Indian Science Congress at Allahabad (Calcutta: Asiatic Society of Bengal), G. Clarke discussed the necessity of increasing the food supply to meet the needs of the growing population in India. From a consideration of the agricultural returns for 1922-23 and 1925-26, it is evident that the area available for food production in India is 1.2 acres per unit population, whereas in America and France, countries comparable with India as regards the importance of agriculture, the corresponding figures are 2.6 and 2.3 respectively. The amount of new land in India suitable for cultivation is no longer sufficient to provide the increased area required, so that the solution of the problem lies in increasing the yield of the land already in use. Weather conditions and the shortness of the growing season are the chief difficulties confronting the agriculturist, but the use of modern methods of research and in particular a closer study of the critical periods of crops, that is, those intervals during which the plant shows maximum sensibility to external factors such as moisture or nitrogen supplies, should do much towards the attainment of better results. Further, green manuring is particularly advocated as an economical means for soil improvement and the maintenance of an adequate nitrogen supply. From a comparison of conditions in other countries and analogy with the progress of the sugar-cane industry in India, it is possible to obtain a rough estimate of the increased production likely to follow the application of scientific methods to agriculture. After making due allowance for the inevitable lag in the adoption of improvements, and taking into consideration the abundant labour resources and responsive nature of the soil in India, it is thought that within the next two or three decades an increased output of 30 per cent. in normal seasons may reasonably be expected. Increased expenditure on scientific research is, however, assumed. — (*Nature*, Vol. CXXVII, No. 3201.)

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

Algin.

Commercial algin is the sodium compound of alginic acid which is present in certain seaweeds of the genus *Laminaria*. The species giving most satisfactory results as a source of algin is *Laminaria digitata*.

The seaweed can be used as a source of iodine and other products of value, in which case it is first macerated with cold water to extract soluble salts. The residue has the appearance of unaltered seaweed. It consists of alginic acid and "algulose" (algic cellulose). The latter makes up the cellular fabric of the plant.

Alginic acid is insoluble in water. It is dissolved out by boiling with a solution of sodium carbonate. Hydrochloric acid is added to precipitate the alginic acid which is separated by filtration. It is then bleached and redissolved in sodium carbonate. The solution is evaporated in vacuum pans to give the algin of commerce.

Algin dissolves slowly in cold water. It resembles gum arabic in general properties, but a two per cent. solution is as viscous as a 50 per cent. solution of gum arabic.

The principal use of algin is as a sizing material in the textile industry. It is also used to stabilise emulsions of various kinds, to thicken colours in printing, and as a mordant. In the dressing of fabrics it is possible to convert algin into the insoluble alginic acid by acidification, thereby making the dressing permanent and the fabric waterproof. Similar results can be obtained by using insoluble salts of alginic acid, such as those of calcium, aluminium, iron, &c.

Algin can also be used as a clarifying agent in the manufacture of beet sugar. For this purpose a suitable quantity of algin is thoroughly mixed with the liquid. A solution of alkaline earth is added, which precipitates the alginic acid together with the colloidal impurities present.

Certain metallic salts of alginic acid have special uses. Iron alginate for example is used in medicine.—(*Bulletin of the Imperial Institute*, July, 1931.)

* * *

The Organic Acids present in Maize Plants.

An investigation has been made by Nelson and Mottern of the organic acids present in the maize plant. The maize was grown in the field, and reaped for examination when at the roasting-ear stage of maturity. The following acids were found to be present in the plant :—aconitic, malic, citric, tricarballylic and oxalic. The amount of oxalic acid in the fresh material was found to be 0.029. The occurrence of aconitic acid in this member of the grass family, as well as in sugar-cane and sorghum, is noteworthy.—(*Journal of American Chemical Society*, August, 1931.)

Spraying of Oranges with Arsenates.

I. The chemical changes observable in ripening oranges during the last hundred days of their growth, have recently been studied in some detail by Copeman (*Trans. Roy. Soc. S. Africa*, XIX, 107, 1931). Particular attention was paid to the contrast between normal oranges and those from trees which had been sprayed with lead arsenate to combat the attacks of insects.

The general results show an increase in soluble solids in the juice during ripening. This includes nitrogen, ash and also sugars. The relative amount of sucrose, glucose and fructose remain constant during this process, although the total amounts increase. Acidity, however, progressively decreases, and this decline is much more marked in fruit from trees which have been sprayed with arsenates. Because of the low content of acid, oranges from sprayed trees may have a characteristically insipid flavour.

The effect of the arsenate is considered to be due chiefly to an intensification of respiration. Since this effect is metabolic in character, variations in the mode of application of the spray are not likely to remove the deleterious action. It seems, therefore, that new methods of combating insect pests in citrus culture must be sought (*Nature*, Vol. CXXVIII, No. 3220).

II. The effect of arsenic sprays upon citrus has also been studied by Takahashi (J. Okitsu, *Hort. Soc. Japan*, XXV, 153, 1930), whose findings in the main agree with those of Copeman. According to Takahashi, however, the reduction in acidity depends greatly on the time of spraying, the amount of the other spraying materials mixed with the arsenate, and the method of application of the spray. Takahashi recommends that excessive use of arsenates should be avoided because of its effect upon the keeping quality of the fruit, but that an occasional arsenic spraying may definitely be beneficial by hastening maturity or reducing excessive acidity.

GRAPEFRUIT.

Imports into Great Britain.

Imports of grapefruit into Great Britain have shown a very great increase during the past decade. In 1921, total imports amounted to no more than 21,449 cwts.; in the following three years they totalled 31,600 cwts.; 50,149 cwts. and 81,367 cwts., respectively, while in 1930 they totalled no less than 556,791 cwts. The great bulk of the grapefruit imported into the United Kingdom comes from the United States, shipments from thence in 1930 amounting to 393,321 cwts. South Africa comes next in order of priority with 46,813 cwts., followed by Cuba with 36,917 cwts. Of the total imports 468,888 cwts. came from foreign countries and 87,903 cwts. from Empire countries. Most of the United States grapefruit shipped to the United Kingdom is grown in Florida, where the harvesting season starts about September and continues to May, with peak supplies about March or April.

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

Crystallizers. *P. Honig* and *W. F. Alewijn.*

In the first part of this contribution, the various types of apparatus for the forced cooling of massecuites which have appeared during the past few years are described. These comprise the Lafeuille, which is well-known and the Werkspoor, recently described. In the Herisson, which has been developed in Natal, cold water is passed through a stirrer of tubes, built into the crystallizer. This apparatus is here criticised on the grounds that apparently more power is necessary than for the Werkspoor, that the massecuite is not uniformly cooled throughout the whole length of the crystallizer, and that the cooling time appears to be very long compared with the Lafeuille and Werkspoor apparatus. A cooler showing some similarity to the Herisson is that patented by C. H. J. Veldkamp and J. L. Ter Hall, though in its design care has been taken to ensure regular cooling throughout the whole length of the crystallizer. Another rapid cooling crystallizer is that patented by the N. V. Constructie Atelier der Vorstenlanden, of Djochakarta, Java, consisting of an entirely rotating crystallizer made of two conical halves, which are fastened together at their greater diameters. Another Dutch apparatus is that made by the N. V. de Ned. Ind. Industrie, which consists of a trough in which there are a number of stationary disc-shaped cooling bodies, in every other one of which above and below there is an opening, through which the massecuite, with the help of a propelling double stirrer, circulates along the cooling bodies through the crystallizer. The cooling bodies are adjustable as to height; and, according to the inventors, existing crystallizers with this apparatus can be converted into the rapid cooling type.

Quite a different construction is the device adopted in the Paauilo factory of the Hamakua Mills, Co., Hawaii. This factory had eight cylindrical crystallizers with a capacity each of about 200 hl. A part of the upper portion of three of them was removed during the 1929 milling season, and around the large upper opening a rim was welded on, then half a dozen groups of two-inch horizontal cooling pipes were welded to the walls of each through which water could be circulated zig-zag fashion. In this manner there was introduced into each crystallizer about 11 sq. metres of cooling surface the stirrers being left so that they could turn between the groups of coils. The cooling time was found to be 84 hours with this device, that is 12 hours shorter than in un-cooled crystallizers, and the massecuite temperature fell to 27°, instead of 33.5°C. Lower purity molasses was not obtained, but fermentation and difficulty in centrifuging were entirely prevented. Yet another type of cooling system is that put on the market by the Frambs and Freudenberg, of Schweidnitz, Germany, using six crystallizers arranged one after the other, this method of operating being combined with the Heil boiling and cooling process. Similar devices have been invented Venditti and Owsiannikow. Strikes are dropped into the first crystallizer with a slight supersaturation and travel the whole length of it with continuous stirring, the crystallizers being provided into parts with bulk-heads with holes in the lower edge. The heaviest crystals sink downward and are the first to be pushed by the stirrer towards the outlet opening, while the finer grain remains suspended passing on so as to grow more. In this way it is expected that after the massecuite has flowed through the five crystallizers one after the other, it will have a larger average crystal than if it had been cooled in the ordinary fashion. — (*Int. Sugar Jr.*, Vol. XXXIII, No. 392.)

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Alcohol as a Fuel for Automobiles. *W. E. Cross.* in "*Rev. Ind. Agr., Tucuman*", Vol. XXI (1931), pp. 5-19.

This article is a review of progress during the past four years in the development of alcohol as a motor fuel. Among the technical advances is the demonstration that high compression is unnecessary in alcohol motors. Experience in many countries has shown that when alcohol is mixed with gasolene, the "knocking" of the motor is greatly reduced, no carbon is deposited, the motor heats up less, there is less consumption of lubricating oil, more power is developed and there is an increase of mileage per litre of fuel.

The manufacture of absolute alcohol by the azeotropic process has been improved and simplified, and the use of alcohol in motor fuels has been made compulsory in many countries. The aviation branch of the United States Navy has approved a mixture of 70 per cent. gasolene and 30 per cent. absolute alcohol as a fuel for airplanes. For common use, alcohol of 95 per cent. is used in mixture with ether or with gasolene and benzol, but on the whole it is more satisfactory to use mixtures of absolute alcohol and gasolene.

In considering measures for promoting this use of alcohol, which is a matter of prime interest to all sugar-producing countries, the author recommends the following :—

1. A simple method of denaturing and the sale of denatured alcohol without restrictions.

2. A requirement that all imported gasolene be mixed with a certain proportion of absolute alcohol before being placed on sale.

3. Fiscal measures to make it possible to sell alcohol in competition with gasolene.

4. The giving of bonuses, tax exemptions, &c., to the manufacturers of fuel alcohol.—(*Facts About Sugar*, Vol. XXVI, No. 9.)

TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.*]

SUGAR.—Prices on the Home Market have ranged as follows: (c.i.f. per cwt.) :—

	Foreign.		*Preferential.*	
	s.	*d.*	*s.*	*d.*
3rd September ..	5	8½	9	4½
10th September ..	5	7½	9	4½
17th September ..	5	5¼	9	3
24th September ..	6	6	10	3
1st October ..	6	6	10	3
8th October ..	6	11	10	7½
15th October ..	6	10½	10	7½

The general tone of the Raw markets during the first part of September remained quiet, there being little material alterations in value. With the suspension of the gold standard in the United Kingdom, however, sugar in common with other commodities, realised higher prices. There has been a particularly heavy demand for Refined sugars from the distributing trade. The future trend of the market and the attainment of a more or less settled sugar price basis will be dependent on the settling down of the value of the Pound abroad. With regard to the statistical position, preliminary estimates by Dr. Mikusch of the European production promise to show a considerable reduction. This authority places the total for Europe, excluding Russia, at 6,447,000 tons, representing a decline in output compared with last season of 2,164,000 tons.

* * *

COCOA.—With the suspension of the gold standard there has been a tendency for prices of all commodities to rise and cocoa has not been an exception. As far as the forward market is concerned which relates chiefly to Accra, there have been some wild fluctuations in sympathy with New York Exchange movements and also the sterling Exchange. The price for Good Fermented Accra is quoted at 25*s*. ($6) and locally $6.50 a fanega for Plantation is being paid.—(*By courtesy of the Cocoa Planters' Association of Trinidad, Limited.*)

* * *

BANANAS.—The demand has continued fair. nce the last Summary prices have been reduced and are now as follows:—Jamaicas, £16 15*s*. per ton delivered London, and £16 10*s*. per ton delivered nearest railway station. Brazilians, £16 10*s*. per ton, delivered nearest railway station. — (*West India Committee Circular*, 17th September.)

TEA.—Latest averages per lb. according to the *Times Trade and Engineering Supplement* (26th September), include: Ceylon, 16.23*d*.; Indian, 11.32*d*.; Java, 7.84*d*. Prices for new season teas are low in comparison with last year.

* * *

RUBBER.—Quotations for Plantation Sheet have ranged as follows:—

	d.
2nd September	2½
9th September	2⅜
16th September	2⅜
23rd September	2 13/16
30th September	2 11/16
7th October	3
14th October	2 15/16

Rubber, after remaining dull for some weeks was, like other commodities, affected by the Government's decision regarding the gold standard when a prompt marking up of prices took place. Prices are likely for some time to be dominated by the uncertainties of the exchange situation.

* * *

COTTON.—The following are the official Spot prices in pence per lb. of the Liverpool Cotton Association:—

	American Mid.	*Egyptian F.G.F. Sakel.*	*Sea Island.*		
			Good.	*Extra fine.*	*Prices paid this Week.*
4th Sept.	3·71	5·60	15·00	30·00	14·75-15·25
11th Sept.	3·70	5·60	15·00	30·00	—
18th Sept.	3 74	6·00	15·00	30·00	—
25th Sept.	5·19	—	15·00	30·00	—
2nd Oct.	4·31	—	15·00	30·00	—
9th Oct.	4·56	—	15·00	30·00	—
16th Oct.	4·81	—	15·00	30·00	—

According to the *Times Trade and Engineering Supplement* the chief event in September was, of course, the suspension of the gold standard. Fears of a depreciated currency and unfavourable exchange rate with the United States of America brought in heavy short coverings, with consequent advance. On the whole, the monetary change has gone through very well in the market and the best authorities take an optimistic view of the outlook. Export trade, specially to the Far East, is expected to improve while the sharp rise in silver is also a favourable factor.

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COFFEE.—There has been little fluctuation in coffee prices. Prices per cwt.: Jamaica, 190*s*.; Costa Rica, 125*s*.; Kenya, good, 80*s*.; Brazil, 40*s*. to 45*s*. The new export tax of 9*s*. per cwt. on Brazilian coffee is likely to encourage the production of "Robusta" coffee, the Brazilian type, in Uganda and Java which have no export taxes.

* * *

COPRA.—The market is slightly easier, with sellers of West Indian f.m.s. asking £11 15*s*. and buyers offering £11 12*s*. 6*d*. West African is quoted in Liverpool at £11 7*s*. 6*d*. to £11 10*s*.—(*West India Committee Circular*, 17th September.)